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THE POMEROY COAL IN OHIO.[1]

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INTRODUCTION.

The Pomeroy coal-seam has long been mined in the state of Ohio, its output having been considerably in excess of 400,000 tons in 1906. It is mined in the three counties, Meigs, Gallia and Lawrence, but from the first named only is it shipped in a large way at the present time. See Fig. 13.

Andrews classed the seam as the Pittsburg and that has heretofore been accepted as correct.[2] Study of this coal in 1907 shows, however, that the seam is not the Pittsburg but a higher one. It is the equivalent of the Redstone coal of Pennsylvania and West Virginia, and the demonstration of this point is the principal burden of this paper.

POSITION AND STRUCTURE OF THE REDSTONE COAL IN PENNSYLVANIA AND WEST VIRGINIA.

This seam was named by Rogers from the exposures on Redstone Creek, Fayette County, Pa. It has been identified at numerous places in that state and also in West Virginia, Maryland and Ohio. As will be shown later its position above the Pittsburg seam ranges usually from twenty to fifty-five feet.

[1] The field work on which this paper is based was done for the Geological Survey of Ohio.

[2] "Geol. Sur. of Ohio," Vol. II, p. 458.

Section on the Beachley farm, near Salisbury, Somerset County, Pa.[1]

	Feet.	Inches.
Surface.		
Redstone Coal.		
Coal	0	2
Parting	0	2½
Coal	0	6
Parting	0	1
Coal	2	3
Clay	0	9
Clay, bituminous	0	2
Slate, black with nodular ore	3	0
Limestone and shale	1	3
Fire clay, impure	1	10
Limestone	10	0
Shales	10	0
Coal, reported	3	0
Shale	4	0
Pittsburg coal	10	0

The limestone between the two coals is reported to be more conspicuous in this territory than the Redstone coal itself.

The relation of the Redstone coal to the Pittsburg in West Virginia is shown in the following section taken on Scott's Run, Monongalia County.[2]

	Feet.	Inches.
Concealed	15	0
Coal, Redstone	4	0
Limestone, Redstone	18	0
Shale and fire clay	5	0
Slate, black	5	0
Coal, Pittsburg.		

The structure of the coal in this state is shown by the following two sections taken in the Century mine in Barbour County.[3]

	Ft.	In.		Ft.	In.
Draw slate	1	0	Bone coal	0	4
Coal	0	7	Coal	5	0
Bone coal	0	½	Slate	0	½
Coal	4	9½	Coal	0	7

[1] Second Geol. Sur. Penn., 3 H, p. 87.
[2] Bull. 65, U. S. G. S., p. 47.
[3] West Va. Geol. Sur., Vol. II., p. 161.

This coal is found in the hills on both sides of the Ohio River in the vicinity of Wheeling, and has been identified by I. C. White as the Redstone seam.[1]

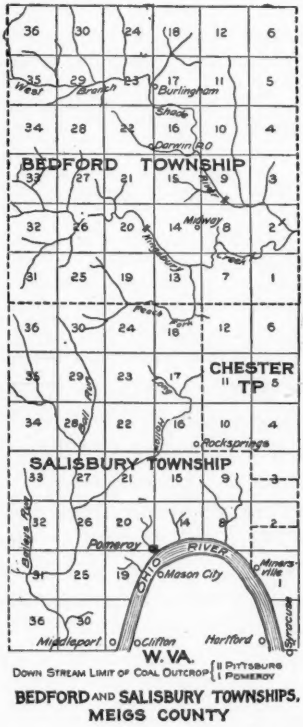

FIG. 13.

THE POMEROY OR REDSTONE COAL FROM BELMONT TO MORGAN COUNTIES.

The discussion which follows will start with territory along the Ohio River opposite Wheeling, and continue in a southwestern direction until Lawrence County, in the extreme southern part of the state, is reached.

[1]Bull. 65, U. S. G. S., pp. 49 and 50.

The following section, made by Mr. J. E. Hyde about one mile west of Bellaire, shows the position and thickness of this seam in the extreme eastern part of the state.

	Feet.	Inches.
Limestone with shaly layers	4	0
Gray argillaceous shale	3	9
Pomeroy *or* **Redstone coal,** *No. 8a*	1	3
Gray argillaceous shale	0	9
Hard gray amorphous limestone with numerous minute fossils	2	0
Gray shale	0	4
Limestone, hard gray amorphous with numerous minute fossils	2	3
Limestone, hard gray amorphous with some fossils	2	0
Shales, hard with some lime and fossils	2	6
Unseen	12	6
Top of **Pittsburg coal,** *No. 8.*		

This section shows thick limestones between the two coals, similar to what have been reported in Pennsylvania and West Virginia. Farther west and southwest in Ohio the limestones are much thinner, but have been traced to the Ohio River at Pomeroy.

Below is a partial record of a diamond drill test made in section 10 of Wayne Township in the southwestern part of Belmont County. Only that part of the record is given which shows the relative positions of the Pomeroy or Redstone and the Pittsburg coals.

	Feet.	Inches.
Limestone	3	4
Soapstone with lime nodules	3	0
Pomeroy *or* **Redstone coal,** *No. 8a. (Coal and shale.)*	1	3
Fire clay	1	0
Gray shale	3	2
Black shale	1	0
Limestone	5	6
Limestone and shale	2	0
Limestone	3	0
Lime, fire clay	2	0
Gray shale with limestone nodules	3	0
Greenish shale	1	6
Dark shale, carbonaceous	3	2

Pittsburg coal.		
Roof coal	0	10
Draw slate	1	0
Coal	5	7
Fire clay	4	1

Frequent exposures of the seam are found in Jefferson County. The following section was measured by the late Professor C. N. Brown in section 22 of Smithfield Township.

	Feet.	Inches.
Shales, exposed	10	0
Pomeroy *or* **Redstone coal,** *No. 8a*	2	1
Clay streak.		
Limestone	2	0
Clay shales	11	0
Pittsburg coal (*Roof coal and shales*)	3	4
Draw slate	1	0
Black slate	0	1
Pittsburg coal (*Breast coal*) *No. 8*	2	4

This section shows an interval of only thirteen feet between the two seams, while in Belmont County, as the sections show, the interval is materially larger.

From Belmont County the coal can be traced southwest through Noble and Morgan counties, but in both of these the exposures of the seam are fewer and thinner.

In his report on the Meigs Creek coal in the last two counties named in the above paragraph, Professor Brown makes occasional mention of a seam lying between the horizon of the Meigs Creek and Pittsburg coals. Thus in Wayne Township in the northeastern part of Noble County, he mentions a faint coal mark at from fifty to fifty-five feet below the Meigs Creek. Likewise he speaks of a thin seam of coal about sixty feet below the Meigs Creek in Elk Township in the southeastern part and in Jackson Township in the southwestern part of the county.[1] The position of this seam is from twenty to thirty feet above the horizon of the Pittsburg in the localities mentioned and it is plainly the Pomeroy or Redstone coal.

In the northern part of Meigsville Township, Morgan County, Professor Brown found the Pomeroy or Redstone coal from

[1]Geol. Sur. of Ohio, Vol. V., chapter XIX.

twelve to twenty inches thick, about twenty-six feet above the Pittsburg seam.

West of the Muskingum River the Pittsburg and Pomeroy coals are very thin or wanting until the southwestern part of the county (Morgan) is reached, where the Pittsburg coal suddenly increases in thickness and becomes a workable seam.

STRUCTURE OF THE PITTSBURG COAL IN SOUTHWESTERN MORGAN AND NORTHERN ATHENS COUNTIES.

It will be well at this point to note the structure of the Pittsburg coal in the territory just referred to where it is commonly known as the Federal Creek seam.

Section of coal in the Waymer bank, near Joy in the southwestern part of Morgan County.

	Feet.	Inches.
Coal, upper bench.		
Coal	1	6
Bone coal	0	8
Clay or shales	0	11
Coal, lower bench.		
Coal	0	2
Parting	0	$\frac{1}{8}$
Coal	0	$7\frac{1}{2}$
Parting	0	$\frac{1}{2}$
Coal	0	3
Parting	0	$\frac{3}{8}$
Coal	0	$1\frac{1}{2}$
Parting	0	$\frac{3}{8}$
Coal	2	0

A few miles farther south, in Athens County, a number of mines exist, three of which ship by rail. In the one at Broadwell the coal was found as follows:

	Feet.	Inches.
Coal, upper bench.		
Coal	1	3
Bone coal	0	$3\frac{1}{2}$
Coal	0	4
Clay or shales	1	0
Coal, lower bench.		
Coal	0	6
Parting		

Coal	0	2
Parting	0	¼
Coal	2	5

These sections are typical for this part of the state. It will be seen that the coal consists of two benches separated by a prominent layer of shales or clay, called soapstone by the miners. This structure of the Pittsburg seam is very persistent in southern Ohio, and may be found wherever the coal exists in anything like normal thickness. It is further illustrated by sections in following pages.

It may be of interest to add analyses and calorific tests of samples taken from the above two mines. All samples referred to in this paper were taken on the plan outlined by Campbell in a previous number of this journal[1] and the analyses and calorific tests were made by Professors Lord and Somermeier.

SAMPLE FROM THE WAYMER MINE.

Ultimate Analysis.		*Proximate Analysis.*	
Carbon	67.39	Moisture	6.87[2]
Hydrogen	5.32	Volatile matter	40.55
Oxygen	13.98	Fixed carbon	44.39
Nitrogen	0.90	Ash	8.19
Sulphur	4.22		100.00
Ash	8.19		
	100.00		

Calorific value ..... 6,722 calories.

This sample included the whole of the lower bench and, with the exception of the Bone coal, the upper bench.

SAMPLE FROM THE BROADWELL MINE.

Ultimate Analysis.		*Proximate Analysis.*	
Carbon	66.61	Moisture	6.60[3]
Hydrogen	5.13	Volatile matter	35.05
Oxygen	13.72	Fixed carbon	48.15
Nitrogen	0.93	Ash	10.20
Sulphur	3.41		100.00
Ash	10.20		
	100.00		

Calorific value ..... 6,607 calories

[1] Vol. II., p. 56.

[2] Sample slightly wet. Moisture possibly 1 per cent. high on this account. Moisture in the air-dried sample about 3 per cent.

[3] Moisture in the air-dried sample about 3 per cent. The sample included the lower bench only.

THE POMEROY COAL FROM THE HOCKING RIVER IN ATHENS COUNTY SOUTH TO THE OHIO RIVER.

In Alexander Township, Athens County, the Pomeroy coal is usually found where due, though frequently it is little more than a blossom. The coal is usually about twenty feet above the Pittsburg.

Near the Bennett mine in section 4 of this township, the following section was measured:

	Feet.	Inches.
Shale, unmeasured.		
Pomeroy coal, *No. 8a*	1	0
Shales with nodular limestone	20	6
Pittsburg coal, *No. 8a*	4	0
Shales	8	0
Sandstone, unmeasured.		

The nodular limestone mentioned in the last two sections is important in the identification of the two coals. It is rarely a foot thick but is persistent and has been traced to the Ohio River at Pomeroy where the lower or Pittsburg coal is not represented by even a black streak. In this part of the state limestones are not common and this fact increases the value of the stratum in question for stratigraphical purposes.

Lodi Township lies east of Alexander and contains the Pomeroy coal where due, the thickness usually ranging from twelve to eighteen inches. Occasionally the coal is underlain by several feet of white limestone. The coal is not mined in the township except where it can be stripped.

Going south from Lodi Township, Bedford Township, Meigs County, is reached. Here the Pomeroy seam is found about twenty feet above the Pittsburg and about twenty inches thick. It is not mined except by stripping.

On the Mayhugh farm in section 21 the coal was found as follows:

	Feet.	Inches.
Coal	0	8
Shales	0	10
Coal	1	8

On the same farm the lower or Pittsburg seam has been mined by stripping in the bed of a creek.

In the southeast corner of this township both coals are well shown and the locality is important in demonstrating the correct position of the Pomeroy seam. About one mile due north of the hamlet Midway the Pittsburg coal is stripped in the bed of a run on the Riggs farm, where the following section was measured:

	Feet.	Inches.
Shales, unmeasured.		
Coal, upper bench	0	3
Clay or shales	1	3
Coal, lower bench.		
Coal	1	0
Shales	0	1
Coal	1	6
Shales	0	1
Coal	1	6

It will be noted that the upper bench here is thin. In fact where the coal contracts this bench suffers most and not infrequently disappears. On the hill between this stripping and Midway the upper or Pomeroy coal is found and the thin limestone below it.

On Kingsbury Creek due south of Midway the Pittsburg coal is below drainage, having dipped below the bed of that stream about one mile farther up, where the following section was measured:

	Feet.	Inches.
Sandstone, unmeasured.		
Shales	2	0
Pomeroy coal	1	6
Shales, blue	8	0
Shales with limestone	11	0
Sandstone, shaly	9	0
Pittsburg coal, unmeasured.		

A few hundred yards up stream from where this section was taken the Pittsburg coal has been stripped in the bed of the creek.

From Kingsbury Creek the Pomeroy coal can be followed up a tributary, Peach Fork, at least three miles.

In following up this tributary one crosses from Bedford Township into Salisbury, which contains the most valuable deposit of the Pomeroy coal above drainage in Ohio. The structure of

the seam along Peach Fork on the northern edge of Salisbury Township is as follows:

	Feet.	Inches.
Sandstone	30	0
Shales	4	0
Pomeroy coal.		
Coal	0	3
Shales	0	1
Coal	1	8
Shales	2+	

The coal has been worked to a very small extent by the farmers. Everywhere along this stream the Pittsburg coal is below drainage and so was not seen. At one place it was reported to have been struck in digging a well, its position being thirty feet below the Pomeroy seam.

Crossing the divide to the southwest from the head of Peach Fork, the valley of Ball Run is entered and the Pomeroy coal is found in similar position and thickness to that on the first named stream. The position of the coal, immediately under the massive sandstone, is important.

Southward on Ball Run the coal increases rapidly in thickness and is mined in a small way at a number of places. It can easily be followed along this stream to the valley of the Ohio. Nowhere in this locality, however, was the Pittsburg coal found, though conditions for its exposure are excellent. In fact it is not represented by even a black streak. At Pomeroy the persistent band of limestone which has already been referred to was found below the Pomeroy coal.

The structure as well as the thickness of the Pomeroy coal changes to the south. On the Gilmore farm, north edge of section 28, Salisbury Township, on Ball's Run, the coal was found as follows:

	Feet.	Inches.
Sandstone	30	0
Coal	1	6
Shales	0	6
Coal	0	4
Clay, unmeasured.		

On the south side of this section the coal measures four feet. Where the coal is thin in Athens and Meigs counties, it is usually divided into two parts by a layer of clay or shales. This structure resembles that of the Pittsburg, but as has been shown the two coals are frequently found on the same hillside and so have not been confused.

THE POMEROY COAL AT POMEROY AND VICINITY.

The structure of the Pomeroy coal at Pomeroy and vicinity forms a marked contrast with that of the Pittsburg seam in southern Ohio. As has already been shown, the Pittsburg consists of two prominent benches of coal separated by a layer of shales or clay, this structure being very persistent. The Pomeroy seam, on the other hand, does not have such a characteristic structure. This is well shown by the following sections:

SECTION IN THE LOGAN MINE, POMEROY.

	Feet.	Inches.
Bone and dirty coal	1	3
Coal	1	8
Parting less than ⅛ inch.		
Coal	0	3
Parting very thin.		
Coal	2	3
Clay, unmeasured.		

SECTION IN THE MINE OF THE PEACOCK COAL CO., POMEROY.

	Feet.	Inches.
Shales, reported thickness	2	0
Impure coal	0	6½
Bone coal	0	5½
Coal	3	3

A few miles up the river the coal was found as follows:

SECTION IN THE BARTEL'S MINE, SYRACUSE.

	Feet.	Inches.
Sandstone, unmeasured.		
Impure coal	0	7½
Horn coal	0	5½
Coal	1	4
Horn coal	0	2½
Coal	2	3½
Clay, unmeasured.		

Still farther up the river, at Antiquity, the coal is mined by shafting, the seam being one hundred feet below low water. The coal is as follows:[1]

	Feet.	Inches.
Coal with a bony band	2	6
Slate	0	2
Coal	3	0

Before proceeding farther several analyses and calorific tests of the Pomeroy coal will be given.

SAMPLE FROM THE LOGAN MINE, POMEROY.

Ultimate Analysis.		*Proximate Analysis.*	
Carbon	66.47	Moisture	7.22[2]
Hydrogen	5.39	Volatile matter	32.82
Oxygen	16.43	Fixed carbon	50.67
Nitrogen	1.10	Ash	9.29
Sulphur	1.32		100.00
Ash	9.29		
	100.00		

Calorific value ..... 6,668 calories.

Here the entire seam was included in the sample, since all the coal is used.

SAMPLE FROM MINE OF THE PEACOCK COAL CO., POMEROY.

Ultimate Analysis.		*Proximate Analysis.*	
Carbon	66.71	Moisture	7.33[3]
Hydrogen	5.53	Volatile matter	34.59
Oxygen	15.96	Fixed carbon	49.39
Nitrogen	1.06	Ash	8.69
Sulphur	2.05		100.00
Ash	8.69		
	100.00		

Calorific value ..... 6,725 calories.

Only the lower part of the bed was included in the sample, that being the only part of the seam shipped. The entire seam is used in the salt furnaces.

[1] "West Va. Geol. Sur.," Vol. II., p. 194.
[2] Moisture in the air-dried sample about 4 per cent.
[3] Moisture in the air-dried sample about 4 per cent.

SAMPLE FROM BARTEL'S MINE, SYRACUSE.

Ultimate Analysis.		*Proximate Analysis.*	
Carbon	65.29	Moisture	4.85[1]
Hydrogen	5.32	Volatile matter	36.28
Oxygen	12.76	Fixed carbon	46.35
Nitrogen	1.17	Ash	12.52
Sulphur	2.94		100.00
Ash	12.52		
	100.00		

Calorific value ..... 6,624 calories.

The entire section of the coal was included in the sample, though seven and one half inches of "impure coal" are sometimes rejected in shipment.

Below is the average of five samples of this seam:

AVERAGE OF COAL ANALYSES, POMEROY AND VICINITY.

Ultimate Analysis.		*Proximate Analysis.*	
Carbon	65.862	Moisture	6.508[2]
Hydrogen	5.368	Volatile matter	35.042
Oxygen	14.844	Fixed carbon	48.048
Nitrogen	1.062	Ash	10.402
Sulphur	2.462		100.000
Ash	10.402		
	100.000		

Calorific value ..... 6,624 calories.

It may not be amiss to give a section on the West Virginia side of the river. The coal was found as follows in the mine of the West Virginia Salt and Coal Company, near Hartford:[3]

	Feet.	Inches.
Sandstone.		
Slate.		
Draw slate	0	1
Coal.		
Top coal	0	7
Horn coal	0	2
Coal	3	9

[1] Moisture in the air-dried sample about 4 per cent.
Moisture in the air-dried samples 4 per cent.
[3] *Ibid.*, p. 193.

Other sections from that side of the river might be given but they would in a large measure duplicate the above.

These sections show a marked difference in structure between the Pomeroy coal and the Pittsburg as found on Federal Creek and vicinity, but a striking resemblance to the Redstone coal of Pennsylvania and West Virginia as shown in the first part of this paper.

THE POMEROY COAL IN GALLIA AND LAWRENCE COUNTIES.

In Gallia County farther west the structure of the Pomeroy coal becomes more simple, consisting generally of a solid block, but occasionally having one or more shale partings.

Both the Pittsburg and Pomeroy coals are found in the eastern part of the western half of Gallia County. Still farther west the Pittsburg seam wholly disappears, leaving the Pomeroy the only seam in the hills and this is thin and of value for domestic purposes only.

Andrews classed the higher of the two seams as the Pomeroy, but the lower or Pittsburg seam he did not correlate with any seam found elsewhere in Ohio. As is well known he regarded the Pomeroy coal as the Pittsburg.

This field furnishes very strong evidence on the position of the Pomeroy coal, for this seam can be followed from hill to hill all the way from Pomeroy to the territory under consideration, and thus the identity of the seam in the two counties is proven.

In at least five townships in Gallia County where the Pomeroy coal exists, another seam is found from about twenty-five to fifty-five feet lower. This seam is in a number of localities much more prominent than the Pomeroy, and is known locally as the Swan Creek, Jeffers or Lewis seam. The structure of the coal is shown in the following sections.

Section in mine of the Swan Creek Coal Co., near Bladen on the Ohio River:

	Feet.	Inches.
Sandstone, massive.		
Shales, reported thickness	2	6
Coal, upper bench	0	4½
Soapstone	1	0
Coal, lower bench	2	9
Clay, unmeasured.		

The section shows the coal of the upper bench thin. It is in fact sometimes wanting in this mine. The soapstone below also varies. Rarely is it more than a foot thick and occasionally it disappears. A sample taken in this mine gave the following results:

Ultimate Analysis.		*Proximate Analysis.*	
Carbon	64.94	Moisture	5.80[1]
Hydrogen	5.16	Volatile matter	36.76
Oxygen	14.40	Fixed carbon	47.38
Nitrogen	1.10	Ash	10.06
Sulphur	4.34		100.00
Ash	10.06		
	100.00		

Calorific value ..... 6,551 calories.[2]

Section in the mine of Samuel Lewis, on Swan Creek, in section of 29 of Ohio Township:

	Feet.	Inches.
Shales, unmeasured.		
Coal, upper bench.		
Coal	1	3
Shales	0	2½
Coal	1	6
Coal and shale	2	7
Clay	0	11
Coal, lower bench	3	0

Here the upper bench is thicker and more complex in structure.

These two sections can be duplicated in large number and in several townships. Generally the upper bench is thin and comparatively unimportant, but occasionally it is of more value than the lower bench. The structure of the coal is strikingly similar to the Pittsburg coal on Federal Creek in Athens and Morgan counties, already given. In both localities the seam is divided into two benches by a bed of clay or shales. Further the rela-

[1] Moisture in the air-dried sample about 3 per cent.

[2] The ultimate analysis and calorific value here given were not obtained until several weeks after the preparation of the fine sample, and laboratory experiments indicate that the sample had increased in weight by oxidation about 1.5 per cent. A calorific value about 100 calories higher than that given, appears to more nearly represent the fresh sample. The sample included both benches of the coal.

tion of the seam in the two localities is similar with reference to the Ames or Crinoidal limestone. That the coal on Federal Creek is the Pittsburg there can be no doubt, and the same conclusion is necessarily reached with reference to the Swan Creek, Jeffers or Lewis seam of Gallia County.

It remains now to show the position of the Pomeroy seam in this territory with reference to the lower or Pittsburg. In or near section 28, Guyan Township, in the southwestern corner of Gallia County, the following section was measured with a hand level:

	Feet.	Inches.
Sandstone	40	0
Coal, Pomeroy or 8a	3	6
Partly covered, sandstone seen	27	0
Coal blossom, Pittsburg or No. 8.		
Shales	15	0

One more section in Gallia County will be given. This is in section 26 of Clay Township, and is taken from Professor Andrew's report.[1]

	Feet.	Inches.
Sandstone, unmeasured.		
Pomeroy coal	1	6
Not exposed	30	0
Sandy shale	10	0
Clay shale	3	0
Top coal	2	0
Ferruginous black slate	2	0
Coal.		
Coal	0	10
Clay	1	0
Coal	3	6
Clay	2	6

While Andrews does not name the lower coal, it is clear from his text that he regards it as the Jeffers seam, which, as has elsewhere been stated, is the Pittsburg. In fact this section was taken at the mine of Abram Jeffers. The "Top coal" of the section is what is elsewhere known as the roof coal of the Pittsburg seam.

In Lawrence County the Pittsburg coal is rarely seen and prob-

[1] "Geol. Sur. of Ohio," Vol. I., p. 240.

ably is never more than a black streak. The following section was obtained in the northwest quarter of section 25 of Mason Township:

	Feet.	Inches.
Sandstone	25 +	
Shales	11	0
Coal, Pomeroy	4	0
Fire clay	2	0
Limestone	1	0
Shales	19	0
Coal blossom, Pittsburg	0	6
Fire clay	1	0

Not only does this section show both coals but also the limestone between them, which, as has already been stated, is important in identifying the two seams.

CONCLUSION.

To the writers the proof is conclusive, the Pomeroy coal lies above the Pittsburg and is the equivalent of the Redstone seam. Since, however, the name Pomeroy is in general use in Ohio it will be retained. The Pittsburg coal being known as No. 8 and the Meigs Creek as No. 9, the Pomeroy seam may appropriately be numbered 8a. For the massive sandstone overlying the Pomeroy coal, the name Pomeroy is proposed.

MAGNETIC OBSERVATIONS IN GEOLOGICAL AND ECONOMIC WORK.

HENRY LLOYD SMYTH.

II.[1] THE MAGNETOMETER AS A HORIZONTAL INSTRUMENT.

CONSTRUCTION AND USE.

Construction.—The Thalén-Tiberg magnetometer (Fig. 14), is a combination instrument designed for making observations in the vertical as well as horizontal plane. For the moment,

FIG. 14.

however, only its use as a horizontal instrument will be considered. From this point of view its essential features are as follows: (1) it has a small compass box *A* containing a two and one fourth inch compass needle, which is well known from the

[1] For Part I. of this paper see ECONOMIC GEOLOGY, Vol. II., No. 4.

description of Haanel[1] and others, swinging inside a graduated circle, the plane of which is horizontal when the instrument is level; (2) an arm *B* about ten inches long is attached to the frame in such a way that its axis lies in the plane of the box; it is therefore horizontal when the instrument is level; (3) the box and arm may be turned freely in azimuth about a vertical axis passing through the pivots of the compass needle, and may be clamped in any desired position; (4) a sleeve *C*, supporting a yoke which may carry a small magnet, called the deviating magnet, slides on the arm, and may be fixed by a set-screw at any convenient point.

Use as a Horizontal Instrument.—In making a magnetic survey with the magnetometer the stations of observations are first established at regular intervals, say fifty feet apart, over the whole field. They should lie on north and south lines, either true or magnetic. At each of these stations an observation of the horizontal needle for *deviation* is made either by the sine method or by the tangent method.

ANGLES OF DEVIATION BY THE SINE METHOD.

1. *Adjustment.*—The instrument is first taken to a station away from the influence of the disturbing matter, and set up, levelled, and the needle released. The deviating magnet is placed in its yoke with the end marked by a brass pin pointing towards the compass box, and the box and arm are turned in azimuth until the needle stands at right angles to the arm, or at the 90° graduations of the circle. The magnet is then lifted from its yoke and carried out of range; whereupon the needle swings back, and finally comes to rest at some angle α_0 with its first position. By moving the sleeve along the arm, the angle α_0 may by trial be made (within limits) to have any desired value, say 30°. The sleeve is then fixed in this position by turning the set-screw. The fixing of the sleeve on the arm in such a position that the angle α_0 in a neutral field—that is to say, away from local magnetic disturbances—has some predetermined value, con-

[1] "On the Location and Examination of Magnetic Ore-deposits by Magnetometric Measurements," Eugene Haanel, Ottawa, 1904.
Mines and Minerals, Vol. XIX., No. 4, November, 1898, pp. 148, 149.

stitutes the adjustment of the instrument for deviation. The angle α_0 is called the *neutral angle.*

2. *Observations.*—At each of the stations of observation the magnetometer is set up, levelled with the compass box horizontal, and after the deviating magnet has been put in place, is turned in azimuth until the needle stands at right angles to the arm. The magnet is then removed, and after the needle has come to rest in its new position, the angle α which this makes with the old is read. This angle is the *angle of deviation.* It varies at different points of the field, and is evidently a function of the distance and direction of the station of observation from the disturbing matter.

3. *Platting the Observations.*—The stations of observation are platted on a map, and at each the observed angle of deviation is written. These angles fall into three classes, namely, those equal to, greater than, or less than the neutral angle. If curves are drawn connecting the points at which the angles are equal (interpolating between the readings), it will be found, if the disturbing matter occurs in a small mass, (1) that the points at which the angle of deviation is equal to the neutral angle not only surround the disturbed area, but are also found along a line, called the *neutral line,* which has a general east and west direction across the field, dividing it into two portions; (2) that the points at which the angle of deviation is greater than the neutral angle form a series of closed, concentric curves lying north of the neutral line; while (3) the points at which the angle of deviation is less than the neutral angle lie south of the neutral line, also on a series of concentric curves. These curves, which are shown in Fig. 2 are called *isodynamic lines.*

4. *Theory of the Sine Method.*—It has already been said that the angle of deviation is evidently a function of the distance and direction of the station of observation from the disturbing material. Also it is evident, in a general way, that this angle, which is produced by combining a constant force with the resultant horizontal force of the field, must bear some inverse relation to that resultant. What then is its precise relation to the forces of

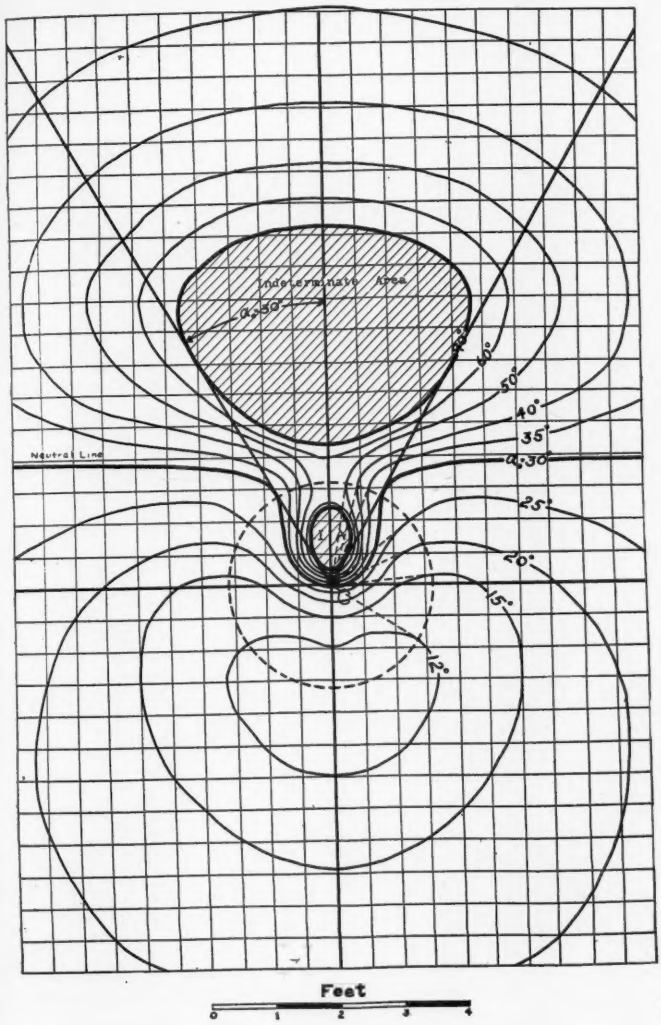

FIG. 15.

the field? In order to answer this question it is necessary to begin with the adjustment for deviation.

Away from the influence of local magnetic material, the horizontal needle is acted on only by the horizontal component of the earth's magnetism. When the deviating magnet is in its yoke and the instrument turned in azimuth until the needle stands at

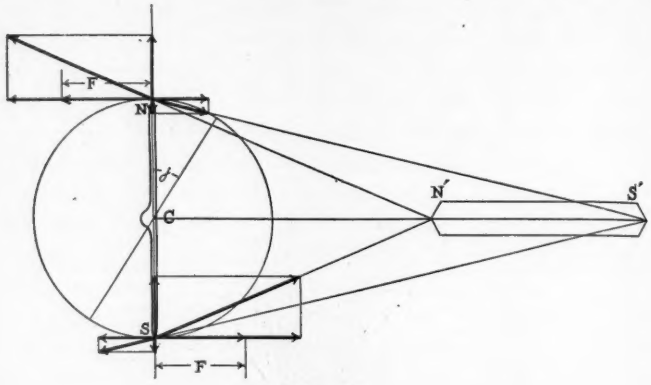

FIG. 16.

90°, or at right angles to the axis of the magnet, it is easy to see (Fig. 16) that the forces exerted by the poles of the magnet on the poles of the needle, may be resolved and composed into equal and opposite forces F, acting at right angles to the needle at its poles, and tending to produce counter-clockwise rotation, and a force acting along the needle, tending to move it bodily away from the spectator, a tendency which is balanced by the resistance of the pivot. The position finally assumed by the needle is the line of the resultant of the force F and the horizontal component of the earth's force H, and to this resultant F is always perpendicular. When F is taken away by moving the magnet out of range, the needle swings back through the angle α_0 to the magnetic meridian. Therefore in the right triangle ABC (Fig. 17) we have

$$F = H \sin \alpha_0. \qquad (1)$$

F will remain the same as long as the magnet is placed at the same distance from the needle, and the magnet and the needle retain their magnetism unchanged; and as long as F is unchanged the angle α_0 will remain the same.

When the adjusted magnetometer is set up within the disturbed area, it is evident that the horizontal needle is acted on by the horizontal component H' of the disturbing matter (Fig. 18), as well

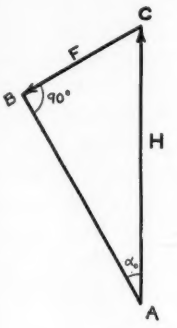

FIG. 17.

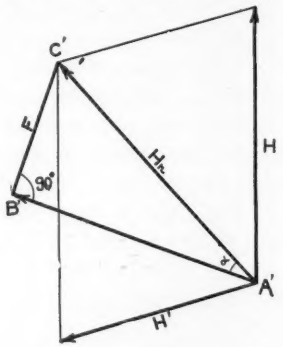

FIG. 18.

as by the horizontal component H of the earth's magnetism, and that it will come to rest in the line of the resultant H_r of these two forces. When the force F is brought into the field by placing the deviating magnet in its yoke, and turning the instrument until the needle rests at 90°, the needle will lie in the line of the resultant of H_r and F, to which resultant F is perpendicular. When F is taken away the needle swings back through the angle α to the line of H_r. Therefore from the right triangle, $A'B'C'$, Fig. 18, we have the following relation between F, H_r and α:

$$F = H_r \sin \alpha. \qquad (2)$$

Substituting in (2) the value of F from (1) we have

$$H_r \sin \alpha = H \sin \alpha_0,$$

$$\sin \alpha = \frac{H}{H_r} \sin \alpha_0. \qquad (3)$$

Since $H \sin \alpha_0$ is constant over the whole field, the variables in (3) are α and H_r. The angle α between 0 and 90° varies with its sine; H_r, as shown in Part I, varies with both the distance and direction of the station of observation from the disturbing matter. In general, it is connected with H and H' by the following equation, in which β is the direction of the station of observation from the pole:

$$H_r^2 = H^2 + H'^2 - 2HH' \cos \beta. \tag{4}$$

The values of the angle α which are platted on the map, and from which the isodynamic curves are constructed, from which in turn, as will be seen hereafter, the form, position, and depth of the magnetic mass are inferred, are therefore only indirectly connected with H', the horizontal component of the disturbing matter. The angle α varies inversely as H_r, and will be greatest where H_r is least and have its least value where H_r is greatest. But, since H_r varies with β independently of H', changes in the value of α do not necessarily signify changes of magnitude in H'.

ANGLES OF DEVIATION BY THE TANGENT METHOD.

In the tangent method, instead of placing the deviating magnet in position before setting the needle at 90°, the needle is first brought to 90°, and then the deviating magnet introduced into the field. Otherwise the operations of adjustment and observation are the same as in the sine method. At the moment the magnet is placed in its yoke, F is perpendicular to the needle. If it be assumed to have the same value when the needle comes to rest in its new position, we have the following relations between F, α_0, α, and H_r:

$$F = H \tan \alpha_0 = H_r \tan \alpha, \tag{5}$$

$$\tan \alpha = \frac{H}{H_r} \tan \alpha_0. \tag{6}$$

Equation (6) is only approximately true, however, because F is not a constant, and hence equations (5) are not simultaneous. It is evident that F must vary with the angle of deviation, which

alters the distances between the poles of the magnet and the poles of the needle.

The manipulation of the instrument in the tangent method is somewhat more rapid than in the sine method, and there is no indeterminate area. These advantages are not sufficient, however, to compensate for its inaccuracy.

THE ISODYNAMIC LINES.

Let us now consider some of the properties of the isodynamic curves when the magnetic force of the disturbing matter is assumed to be concentrated at a single pole, having north polar magnetism, located in or not far below its upper surface, and at a depth h below the horizontal plane on which the stations of observations are situated.

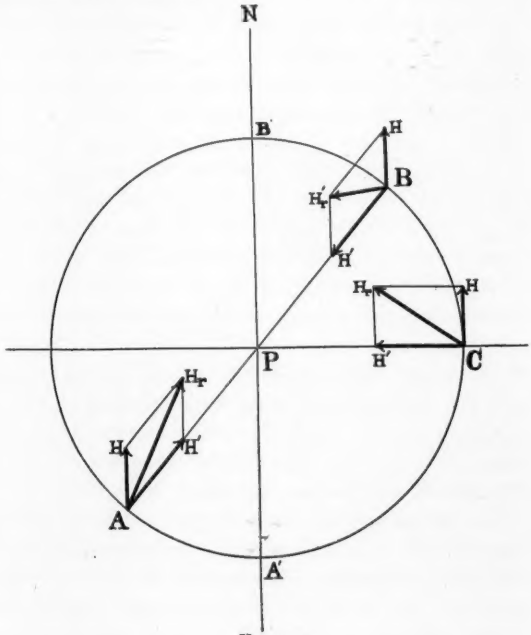

FIG. 19.

The Magnetic Meridian.—Let P, Fig. 19, be the point on the surface over the pole of the disturbing matter, that is to say, the point at which H' becomes 0; let PN be the magnetic meridian through P, and let A and B be a pair of stations on the same straight line passing through P, but on opposite sides and equally distant from it. The angle NPB is β. Then from the parallelograms of force at A and B

$$H_r^2 = H^2 + H'^2 + 2HH' \cos \beta, \tag{7}$$

$$H_r'^2 = H^2 + H'^2 - 2HH' \cos \beta. \tag{8}$$

If β varies, the distances PA and PB remaining unchanged, H_r and H_r' will vary also, the maximum and minimum values being found when β becomes zero, and the points are situated on the magnetic meridian at A' and B'. The same thing is evidently true of all other similar pairs of points, and hence it follows that the greatest and least values of H_r are found at points situated on that magnetic meridian which passes through the pole of the disturbing matter. The greatest and least values of H_r in the whole disturbed area are found at those stations at which the angles of deviation are respectively least and greatest; therefore these stations are determinable on the ground and on the map. Evidently they must correspond with the central points of the two concentric sets of isodynamic curves. Hence the pole of the ore-body lies somewhere on the line joining these central points, and this line is accordingly the magnetic meridian through P.

The Neutral Line.—The neutral line is the line drawn through all the points in the disturbed area at which the angle of deviation α is equal to the neutral angle α_0. Therefore at points on the neutral line H_r equals H. But at the point over the pole H_r equals H, since H' equals zero; therefore the neutral line passes through this station, which must accordingly be situated at its intersection with the magnetic meridian just determined.

The following properties of the neutral line are of interest.

1. *The neutral line is tangent to the east and west line through P, at P; elsewhere it lies north of it.* For in equation (4) if we

make $H_r = H, \cos\beta = H'/2H$, and therefore at the pole, where $H' = 0$, $\cos\beta = 0$, or $\beta = 90°$. At all other points on the east and west line H_r is greater than H, Fig. 19; and these points are therefore south of the neutral line.

2. *The form of the neutral line depends on the ratio of H' to $2H$.* For in the equation $\cos\beta = H'/2H$, if the maximum

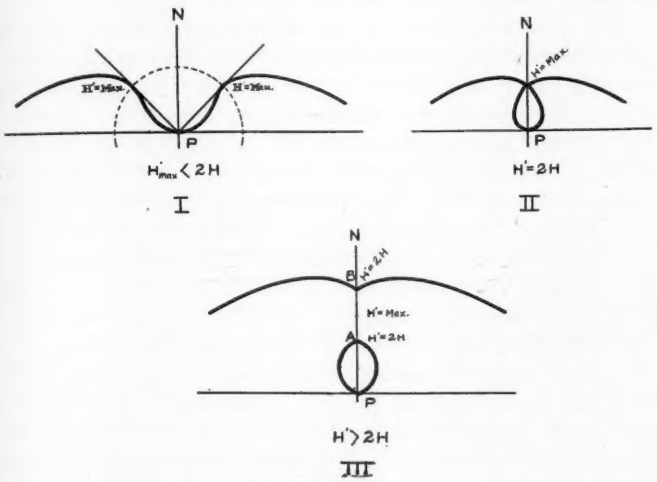

FIG. 20.

value of H' is less than $2H$, the maximum value of $\cos\beta$ is less than 1, the minimum value of β is greater than 0, and the neutral line will be continuous on each side of the meridian. If (Fig. 20, *I*) two lines be drawn through P making the minimum value of β with the magnetic meridian on each side, they will be tangent to the neutral line at the point where H' is a maximum. Or otherwise stated, *tangents to the neutral line drawn through P will touch it at the points where H' is a maximum.*

If the maximum value of H' equals $2H$, $\beta = 0$, and the neutral line will touch the magnetic meridian north of the pole, at the point where H' is a maximum (Fig. 20, *II*).

If the maximum value of H' is greater than $2H$, $\cos\beta$ will be

greater than 1, and β will be imaginary through a certain range of values of H'. In this case the neutral line is found in two discontinuous branches, between which, on the meridian, is situated the point at which H' is a maximum, as shown in Fig. 20, *III*. The points A and B correspond to $\cos\beta = 1$, or $H' = 2H$. Through the distance A to B, for which β has no real values, H' is greater than $2H$.

The Maximum Line.—It has already been shown that the greatest and least values of H_r are found on the magnetic meridian at points equally distant from P. At the southern of these *points* $H_r = H + H'$; and at the northern $H_r = H - H'$, as readily appears from equations (7) and (8). These values of H_r correspond to maximum values of H', and accordingly these two points, which are the centers of the two systems of concentric curves, are two points on the maximum line. Other points are found by drawing (as in Fig. 15) through P a series of tangents to the isodynamic lines; as is easily seen, the points of tangency are points at which H' is a maximum. For, in a series of observations for deviation along any tangent, the greatest or least value of α, corresponding to the least or greatest value of H_r, will evidently be found at the point of tangency; and since β, the direction angle of H', is constant throughout the series, and therefore variation in H_r can result only from change in the numerical value of H', the point of tangency must be the point at which H' is a maximum. The *maximum line*, or the line joining all these points of tangency, is a circle in the particular case which we are now considering.

The Indeterminate Area.—North of the neutral line there may be either one or two areas within which the angle of deviation cannot be determined, and which are therefore called *indeterminate areas.* It is impossible to get a reading for deviation at stations within them because the compass needle cannot be set at right angles to the deflecting magnet. The explanation of this fact is as follows:

From equation (3), $\sin\alpha = H/H_r \sin\alpha_0$, we see that the condition for real values of α is that $\sin\alpha$ should be equal to or less than 1, or that $H \sin\alpha_0$ should be equal to or less than H_r.

South of the neutral line H_r is always greater than H, and therefore still greater than $H \sin \alpha_0$; hence, real values of α are found at all stations in this division of the field. But north of the neutral line, where H' and H act in generally opposite directions, H_r may be less than $H \sin \alpha_0$ if H' is sufficiently great. At stations where this is the case $\sin \alpha > 1$, which value of course corresponds to no real angle α. At these stations, then, no determination of α is possible.

Whether we have one indeterminate area, or two, or none at all, depends on the magnitude of H' at its maximum. For let us follow the successive values of H' on the magnetic meridian north of the neutral line. At P, the starting point, H' equals zero, while north of P it first increases to a maximum, say at M (Fig. 21), and then beyond M decreases again, reaching zero at

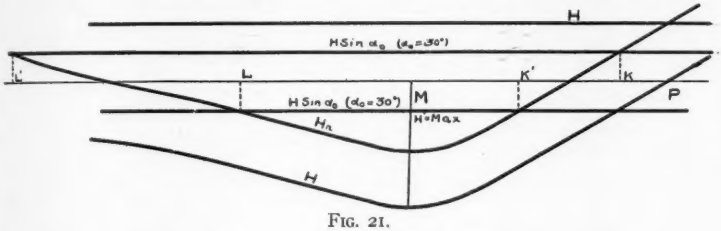

FIG. 21.

the margin of the disturbed area. North of the neutral line on the magnetic meridian, H_r is equal to the numerical difference of H and H', or $H_r = H - H'$. As H' increases in going north on the meridian H_r diminishes, until, when $H' = H(1 - \sin \alpha_0)$, the value $H \sin \alpha_0$ is reached, and the indeterminate area begins. If the maximum value of H' is sufficiently great, H_r will continue to diminish, and after passing through the value 0 when $H' = H$, will have negative values. The negative values will continue to increase numerically until $H_r = -H \sin \alpha_0$, when $\sin \alpha$ will become -1, and α will again become determinate. The values of α will diminish as H_r increases, until the point is reached at which H' is a maximum. North of this point H' will diminish, and H_r will go through the same sequence of values in reverse order, a second indeterminate area occurring between

$H_r = -H \sin \alpha_0$, and $H_r = H \sin \alpha_0$. These facts are shown in Fig. 21, where the values of H' and H_r are plotted as continuous curves. From K to K' and from L to L', where H_r is numerically less than $H \sin \alpha_0$, the values of α are indeterminate.

If through P we draw lines on each side of the magnetic meridian, making with it the angle α_0, these lines will be tangent to the indeterminate areas. For take any point A the direction angle of which from P is β. Then at A,

$$H_r^2 = H^2 + H'^2 - 2HH' \cos \beta. \tag{4}$$

The condition that A should lie on the edge of the indeterminate area is that $\sin \alpha = 1$, or $H_r = H \sin \alpha_0$.
Substituting this value of H_r in (4), we have

$$H^2 \sin^2 \alpha_0 = H^2 + H'^2 - 2HH' \cos \beta \tag{9}$$

$$H'^2 - 2HH' \cos \beta = H^2 (\sin^2 \alpha_0 - 1),$$

$$(H' - H \cos \beta)^2 = H^2 (\sin^2 \alpha_0 + \cos^2 \beta - 1).$$

The condition for real values of H' is

$$\sin^2 \alpha_0 + \cos^2 \beta \gtrless 1,$$

or

$$\cos^2 \beta \gtrless 1 - \sin^2 \alpha_0,$$

or

$$\beta \leqq \alpha_0.$$

For all values of β less than α_0 there are two real values of H' (each of which may be passed through twice), which satisfy these conditions and lie on the edges of the indeterminate areas; where $\beta = \alpha_0$, there is but one real and positive value of H', which, however, may be passed through twice, which satisfies the conditions and corresponds to points on the edges of the indeterminate areas; when β is greater than α_0, H' has no real values. Hence the line $\beta = \alpha_0$ is tangent to the indeterminate areas. Fig. 15, which represents the survey of a field of disturbance produced by a long vertical electro-magnet, shows two indeterminate areas tangent to the pair of lines drawn through P

making the angle α_0 with the magnetic meridian. It is evident that the indeterminate areas may be diminished or increased by choosing a small or large value for α_0.

THE SURVEY OF A MAGNETIC STRIP.

Let us now consider the application of the magnetometer to the survey of a magnetic strip having the properties assumed in Part I,[1] namely, uniform width and great proportionate length, uniform strike, a level upper surface over which magnetism is uniformly distributed, and a uniformly deep cover of non-magnetic matter. It has already been said that such a strip more or less closely represents a not infrequent type of magnetic rock. It has also been shown that H', the horizontal component of the magnetic force exerted by a strip, acts in parallel lines, at right angles to the strike of the strip, over the whole field. It will be desirable to consider the character of the isodynamic lines for three different orientations, namely, when the strip strikes (1) north and south, (2) east and west, and (3) in an intermediate direction.

1. *A Strip Striking North and South.*—If the strike is north and south it is evident (Fig. 22) that the isodynamic lines will all

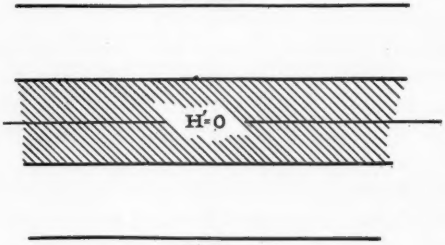

FIG. 22.

be parallel with it, and that the neutral line, being the locus of the points at which H_r equals H, will lie over the middle of the strip and be the magnetic line. Evidently also, H_r will be greater than

[1] ECON. GEOL., Vol. II., No. 4, June, 1907, pp. 374–375.

H, and the angles of deviation less than the neutral angle, over the rest of the field. The least angles of deviation, corresponding to maximum values of H_r and H', will be situated on two straight lines parallel to the neutral line and on either side of it. These will be the maximum lines. There will be no indeterminate area.

2. *A Strip Striking East and West.*—If the strike is east and west (Fig. 23), the neutral line will run east and west over the

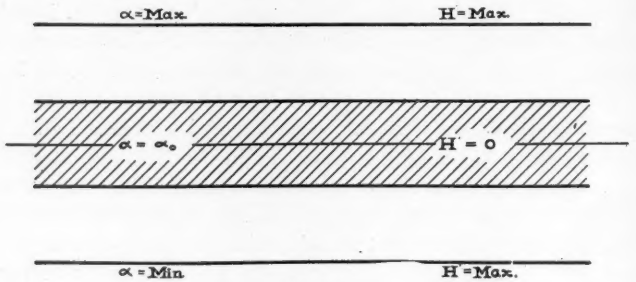

FIG. 23.

middle of the strip, and will constitute the magnetic line. A line of maximum deviation is found to the north, and a line of minimum deviation to the south of the neutral lines at equal distances from it. These are the maximum lines.

If the maximum value of H' is so large that H_r passes through values less than $H \sin \alpha_0$, there will be either one or two indeterminate areas north of the disturbing material and parallel with it. If there are two indeterminate strips, the northern maximum line will be situated between them.

3. *A Strip Striking North of East or West.*—In this, as in the cases just considered, the neutral line will lie over the middle of the strip, and will become the magnetic line (Fig. 24). The lines of maximum and minimum deviation,—the maximum lines,—will be situated on each side of the neutral line at equal distances from it, the former on the north, the latter on the south side. On the north side, also, depending on the maximum value of H' and on the angle of strike, there may be one or two

indeterminate areas. If the strike is less than the complement of the neutral angle, there can be no indeterminate area, no matter

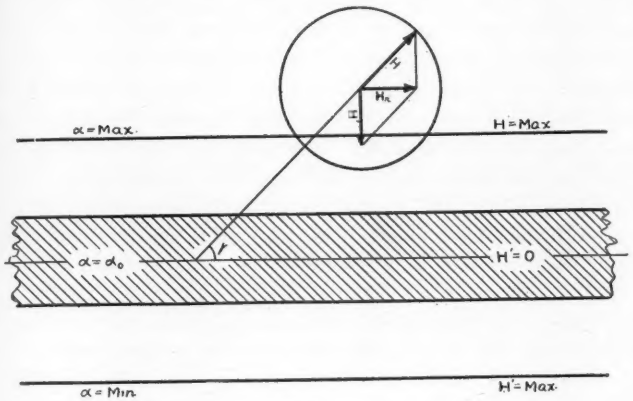

FIG. 24.

how great H' may be. For, in Fig. 24, if γ be the strike of the strip,

$$H_r^2 = H^2 + H'^2 - 2HH' \sin \gamma.$$

H_r is a minimum when $H' = H \sin \gamma$, and therefore

$$H_r^2 = H^2 (1 - \sin^2 \gamma) = H^2 \cos^2 \gamma;$$

or

$$H_r = H \cos \gamma.$$

Substituting this value of H_r in equation (3) we have

$$\sin \alpha = \frac{H}{H_r} \sin \alpha_0 = \frac{H \sin \alpha_0}{H \cos \gamma} = \frac{\sin \alpha_0}{\cos \gamma};$$

from which it is evident that α is real, and therefore there can be no indeterminate area, when γ is equal to or less than $90° - \alpha_0$. If γ is greater than $90° - \alpha_0$ there may be one or two indeterminate areas if H' is sufficiently large.

INTERPRETATION OF THE RESULTS.

The isodynamic lines resulting from the magnetic survey of a small mass have no obvious relation to its position or form; all that can be said is that the closed curves are flattened or drawn out in general parallelism with the long horizontal axis of the deposit. From these curves, however, as has been shown, we may determine the magnetic meridian through the pole of the mass, and the critical points,[1] that is to say, the point over the pole, and the maximum line or lines. The inferences as to the depth, strike, dip, and boundaries of the deposit are made from these critical points, as set forth in Part I., pp. 372–374, 378–379. These considerations need not be repeated here.

Where the disturbing matter is a vertically dipping bed of magnetite or magnetic rock, which may be represented as a magnetized strip, the isodynamic curves become straight lines, some of which are the *loci* of the critical points as has just been shown. Thus the neutral line becomes the magnetic line, while the maximum lines are the isodynamic lines of maximum or minimum deviation. The strike, boundaries, and depth of the magnetic rock, and its direction of dip, if it is inclined at an angle less than 90°, are inferred from these data in accordance with the principles stated in Part I., pp. 374–378.

COMPARISON OF THE MAGNETOMETER AND THE DIAL-COMPASS.

From the foregoing it appears that the function of the Thalén-Tiberg magnetometer, used as a horizontal instrument, is to determine the critical points of the disturbed area; and therefore it does exactly the same work as the dial-compass, although the results are reached in a different way. With neither instrument are they reached by direct measurement of H'. With the magnetometer the critical points are determined by a comparison of the magnitudes at the several stations of the resultant horizontal force of the field; and with the dial-compass by a comparison of the directions of this resultant. It is upon these critical points that the inferences are based as to the strike, dip, depth, and

[1] ECON. GEOL., Vol. II., No. 4, June, 1907, pp. 372, 376, 378.

boundaries of the disturbing matter, and these inferences are of course independent of the manner in which the data have been obtained.

While both instruments lead to precisely the same result, it is by no means to be inferred that one is as convenient as the other for observation of the horizontal force of the field. The dial-compass requires sunlight, and its working day is shorter, for whenever much accuracy is required, it cannot be used in the early morning and late afternoon. Furthermore it cannot locate the maximum lines in the case of a uniformly magnetized strip striking east and west. But in most other respects (and given good weather conditions) it is a more desirable instrument than the magnetometer. It is cheaper, more portable, and may be set up and read more quickly. Its greatest merit, however, is that it determines its own meridian, and hence is available for establishing its own stations, while the magnetometer generally requires a previous survey with a transit in order to fix the points of observation. Furthermore, time is saved not only by dispensing with the preliminary survey, but by cutting out unnecessary work afterwards. For with the magnetometer the critical points are not determinable until the survey has covered the whole field, and the isodynamic lines are drawn; and, since the position of the maximum lines depends on the accurate delineation of these curves, it is important to occupy every station. With the dial-compass, on the other hand, usually the general position of the disturbing matter may quickly be determined by a rapid reconnoissance, and the subsequent work at once laid out so that it may all tell directly in the determination of the critical points.

The magnetometer is unquestionably a somewhat more precise instrument, not in the sense that it may be read more closely, but because it is free from the small inaccuracies to which the dial-compass is subject through errors in time and latitude. But in most cases this added precision in no way improves the inferences as to the boundaries, attitude, and depth of the disturbing matter. At the best these inferences, as has been shown in Part I., are only roughly quantitative. Indeed in practice, the position of the critical points, upon which these inferences are based,

is generally vastly more affected by irregularities in topography and in the upper surface of the magnetic material, than by any possible difference in the precision of the instruments. Fig. 25

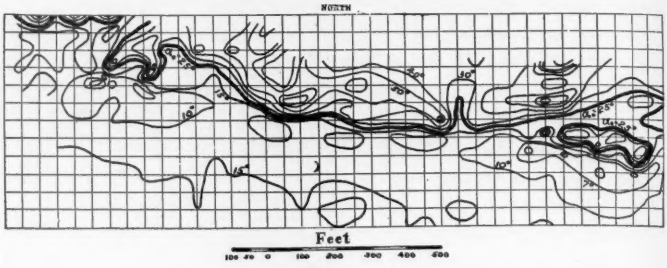

FIG. 25.

shows on a very small scale the isodynamic lines produced by a belt of magnetic rock of practically uniform width which outcrops freely in a rough country. While the general direction of the isodynamic lines is parallel with the strike, their course in detail is extremely irregular. The departures from uniformity of direction are only in small part caused by irregularity in the distribution of magnetite through the rock. The main reason is the roughness of the surface, in consequence of which magnetic material frequently stood close beside the instrument or even above it at many of the stations of observation. In such a field precision in reading is evidently thrown away; and indeed any magnetic survey, except the roughest, is of very little use. For an account of the numerous exposures of rock, all the information obtainable through a magnetic survey could better have been obtained by mapping and studying the outcrops. It need hardly be said that the proper function of magnetic surveys is to deal with hidden magnetic matter—with things unseen rather than with things seen.

THE LIGNITE OF MISSISSIPPI.

CALVIN S. BROWN.

The experiments of the coal-testing plant of the United States Geological Survey at St. Louis have added a new interest to lignite. The result of these investigations is summed up as follows on page 30 of the report of that plant.

"It has been shown that a gas of higher quality can be obtained from lignite than from high-grade bituminous coals, and that 1 ton of lignite used in a gas-producer plant will yield as much power as the best Pennsylvania or West Virginia bituminous coals used under boilers. It appears, in fact, that as coals decline in value when measured by their steam-raising power, they increase in value comparatively as a fuel for the gas producer. The brown lignites on which tests were made at the coal-testing plant were from North Dakota and Texas, and the unexpectedly high power-producing qualities developed by them in the gas producer and gas engine give promise of large future developments in these and other States."

The old reports on the geology of Mississippi by Wailes in 1854, by Harper in 1857, and especially by Hilgard in 1860, made frequent mention of the occurrence of lignite in the State; and from that time up to the present the newspapers have often reported the discovery of lignite or "coal" in various parts of Mississippi. Upon the reorganization of the State Geological Survey in 1906 Mr. Albert F. Crider, the director of the Survey, requested the writer to make an examination of the lignite resources of the State and report on them. During the summer of 1906 two and a half months were spent in the field, and about two hundred outcrops were examined. From these fifty samples were taken for analysis.

The lignite area of the state lies north of the railroad through Vicksburg, Jackson, and Meridian, and east of the Bluff. The

outcrops occurring south of this limit are relatively infrequent and unimportant. No lignite is found west of the Bluff in the low level territory known as the Delta.

The north central area of the State in which the lignite occurs has an elevation ranging from 200 to 700 feet above the sea and is characterized by a rough hilly surface frequently cut by deep gullies. A large part of the mantle rock being sand, erosion is going on constantly and consequently the surface of the country is changing rapidly.

The formation in which the larger part of the lignite occurs is that called by Dr. Hilgard the Northern Lignitic, now generally called the Wilcox. This, as well as the Claiborne, the next in importance as a lignite-bearing formation, is Tertiary in age. Some of the lignite further east, that in Itawauba County for instance, is Cretaceous. Lignites are also found associated with the Jackson, Vicksburg, and Grand Gulf formations in the central part of the State.

The Mississippi lignite often occurs near the surface, being frequently exposed in gullies or ravines and in the beds of streams. Springs often form a good index to its outcrop, for both lignite and the clays associated with it are impervious to water; hence the surface waters which find their way readily through the Lafayette sand are deflected when they strike the lignite or the associated clay and flow along these strata till they find an outlet at some lower level. Lignite is frequently struck in digging or boring wells, and sometimes in railroad cuts.

The materials most closely associated with lignite are usually the various types of sands and clays. Sands are generally found at no great distance above the lignite. Immediately above it, however, is frequently found a few feet of clay. No stone or slate roofing of consequence is found over the lignite beds of Mississippi. It sometimes happens, however, that the last inch or two of a sand layer resting directly upon a deposit of lignite is converted into ferruginous sandstone by a cement of iron oxide from a flow of iron-impregnated water arrested in its downward course by the bed of lignite. Immediately below the lignite is

usually found clay, sometimes of excellent quality. Not infrequently the underlying clay is deeply colored with lignitic matter. The associated sands are also sometimes carbonaceous in character. I was not able in every case to determine the thickness of the deposits of lignite. In many cases the beds are very thin, and beds beyond three feet in thickness are not very common, while those beyond five feet are unusual. The thickest strata which I was able to find are the following:

1. "Burning bed," near Lexington, Holmes Co. (Sample No. 21), thickness 7⅓ to 8 feet.

2. Shenoah Hill, Holmes Co., thickness 5 to 6 feet.

3. Coal Bluff, on Pearl River (Sample No. 18), thickness somewhat over 5 feet.

It should be said, however, that greater thicknesses than these have been reported by others.

The persistence of the beds, both as to thickness and as to lateral extent, is by no means certain among the Mississippi lignites. Beds change in thickness with remarkable rapidity, often thinning out or even disappearing within a few yards. A good outcrop on one side of a hill may not reappear at all on the opposite side of the hill a quarter of a mile away, or may not be found even across the valley or ravine twenty yards distant. The uniformity and continuity of stratum so desirable for mining is frequently wanting. In the railroad cut near Topton, Lauderdale County, for instance, a stratum of poor lignite or lignitic shale between 3 and 4 feet thick practically disappears in both directions at a distance of 50 yards. In the "burning bed" in Holmes County the lignite seems to thin out in every direction from a point where it is about 8 feet thick. It would seem that in general the lignite has been deposited in lenticular masses and that the diameter of the lens is often small.

The quality of the lignite differs greatly in different deposits, running through all the gradations from lignitic shale and clay to a compact, pure, dark brown lignite. In some places it is difficult to determine whether we should call the material lignitic clay or mucky lignite, lignitic shale or shaly lignite. In some

beds the deposit is moist and soft, in others dry and firm. In some beds the plant remains are abundant and wood may be found but slightly altered, in others the material is completely lignitized. In some beds much iron pyrite or other impurity is found, in others very little. The chemical composition, as will be seen further on, varies greatly in different beds. Not only do the beds differ one from another in quality, but there will often be found great difference in quality within the same bed. The upper part of a stratum may be soft and mucky, while the lower part is hard and compact. The upper part may be comparatively pure and good, while the lower part may contain much clay or earth. The bulk of a bed may be completely lignitized while a small part of it is but imperfectly converted; occasionally the same trunk may be partly lignitized and partly petrified. The bed at Coal Bluff on Pearl River shows this variation in quality; at one place the partial section is as follows:

Lignitic shale	3¼	feet.
Solid lignite	17	inches.
Laminated lignite	3	feet.

The counties which seem to offer the best opportunities for the development of lignite are Lafayette, Calhoun, Choctaw, and Holmes, although Panolo, Yalohusha, Webster, Winston, Kemper, and other counties have good deposits. The strata of Holmes County are the thickest in the State so far as investigated. One of these lying six miles southeast of Lexington is eight feet thick and is interesting in the fact that it has been on fire for a number of years. The Calhoun county lignites are to be noted as being especially free from sulphur.

The following analyses will give an idea of the value of the better Mississippi lignites:

ANALYSES OF MISSISSIPPI LIGNITES.
By Dr. W. F. Hand (air-dried basis).

No.	Locality.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Total.	Sulfur.	B. T. U.
2	Panola Co.	13.93	44.65	35.17	6.25	100	.70	9,930
7	Choctaw Co.	11.39	39.79	38.72	10.10	100	2.83	9,425
10	Choctaw Co.	11.61	34.61	42.47	11.31	100	2.66	10,071
11	Choctaw Co.	11.07	42.92	39.70	6.31	100	1.92	9,947
13	Winston Co.	11.59	37.49	43.76	7.16	100	1.29	9,819
14	Winston Co.	14.20	35.24	41.80	8.76	100	.63	9,459
16	Kemper Co.	13.61	37.14	42.10	7.15	100	2.64	9,790
21	Holmes Co.	13.87	36.32	34.46	15.36	100	1.39	8,426
23	Holmes Co.	15.22	42.38	34.91	7.49	100	.91	9,201
40	Webster Co.	14.90	39.21	35.57	10.32	100	.56	9,117
44	Calhoun Co.	11.46	40.74	37.59	10.21	100	.78	9,875
45	Calhoun Co.	12.26	37.43	41.94	6.37	100	.94	9,959
48	Lafayette Co.	14.61	38.51	39.10	7.78	100	1.28	9,398
50	Lafayette Co.	14.60	38.59	35.21	11.60	100	1.83	8,780

ANALYSES OF MISSISSIPPI LIGNITES.
By Prof. S. W. Parr (dry basis).

No.	Locality.	Carbon.	Available Hydrogen.	Ash.	Sulfur.	B. T. U.
14	Winston Co.	60.56	1.85	12.55	.76	9,986
23	Holmes Co.	59.10	2.70	14.44	.84	10,310
25	Panola Co.	59.70	2.42	12.48	.73	10,217
43	Calhoun Co.	58.83	1.86	13.35	4.18	9,878
46	Yalobusha Co.	64.90	2.55	5.23	1.17	11,068
48	Lafayette Co.	62.96	2.03	9.00	1.28	10,467
50	Lafayette Co.	57.38	1.76	13.08	2.00	9,520
Av.		60.49	2.17	11.44	1.56	10,206

DISCUSSION

This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

LOCALIZATION OF VALUES IN ORE-BODIES AND OCCURRENCE OF "SHOOTS" IN METALLIFEROUS DEPOSITS.

In consideration of Mr. Irving's proposition: "that values in ore-bodies occur in 'shoots,' and that only the most careful sampling will bring out the fact that all portions of a vein or ore-body are not of equal value," referring more generally to precious metal deposits, it seems to the writer to be more or less advisable to attach much less importance to "shoots" as a form of localization of values (asking permission to substitute the word "chutes," for reasons referable to definition and derivation) than to other forms of value-localization; especially since chutes, properly speaking, seem to be of less frequent occurrence than the ordinary zones or channels of local enrichment, and also seem to offer relatively less difficulty to the sampler when identified. In support of this proposition it might be well to give an example of the writer's conception of an ore-chute, and to offer a rough definition thereof.

The fissure vein of the Holy Terror mine, at Keystone, South Dakota, was enclosed in Algonkian schists, in a region which had suffered pronounced disturbance from the granitic uplift. It approached, both in dip and strike, the neighboring and much larger vein of the Keystone mine, which seems to be a portion of the immense fahlband which stretches southerly from the

vicinity of the Homestake mine at Lead City. The evidence obtainable seemed to indicate a later and dependent deposition for the Holy Terror vein. In this mine a typical ore-chute extended without break from the surface to the 300-level; commencing somewhat southerly of the shaft the chute pitched northerly along the vein, its major axis having an inclination or dip of possibly 45 degrees. At the 300-level the vein had departed from the perpendicular, so that a short cross-cut was necessary. In the northerly drift from face of this cross-cut the chute was cut in a distance of something like 300 feet along the vein. The ore-chute consisted of a lens, thinning out at the edges from a maximum central thickness of about 12 feet, and was made up of vitreous, smoky quartz carrying high values in free gold and sulphides. Southward of this chute, in other parts of the mine and notably in the south drift from the cross-cut on the 300-level, the main vein was widely exposed and consisted of white opaque quartz containing some sulphides and more or less stained with oxide of iron; it was a somewhat softer and looser material than that of the chute, and contained no great commercial values except in certain eccentric spots which consisted of smoky quartz similar to that of the chute. If the foregoing may be considered a fairly reasonable example of an ore-chute, such an ore-body might be defined as follows: A more or less roughly lenticular body of ore, included in the plane of the vein proper and conforming to the shape of the limiting fissure, whose major axis usually pitches along the vein at a smaller angle than the dip of the vein; frequently showing evidence of later deposition than the vein, as well as higher values.

Ore-chutes of this nature consist of more or less homogeneous ore-bodies, of somewhat limited extent, and usually give comparatively little trouble in their sampling. Of course, they are subject to distortion, faulting etc., etc., but less frequently, it is likely, than the older deposit. Compared with many other examples of local enrichment (a few of which are given below) experience seems to justify the belief that an estimate of their values by sampling is a much less difficult matter.

In the examination of ore-bodies showing evidence of such

conditions of localization of values as the following: (*a*) Along more or less regular zones of fracture, (*b*) along eccentric fault-fissures, (*c*) along zones of final deposition or replacement, (*d*) in various country-rocks along either wall of relatively barren veins, or (*e*) in portions of veins adjacent to faulting dikes or secondary veins, the character of the ore-body may not long remain obscure, but its recognition immediately suggests an intricate and painstaking task in connection with a safe estimate of its value. In addition to the difficulty in getting samples which "mean anything," the engineer is limited to the use of the greatest care in his interpretation of results. But a few years of mining experience may suffice to supply a very wide variety of strange conditions, containing many apparent paradoxes, and retrospect inavoidably suggests a probable lack of safety in the application of fixed rules. (One remembers, for instance, an ancient admiration for Schmidt's Rule of the Obtuse Angle, with a feeling of regret that its practical use seems never to have "bobbed up" with any great degree of efficiency.) By no means wishing to undervalue the great benefit of scientific discussion and criticism, it is still a fact that experience seems to suggest the formulation of certain axioms; something in the following line:

When the commercial consideration is involved, few rules deduced from study of one ore-deposit will safely apply to another; generalization based upon particular conditions is unsafe.

Only close association with certain deposits for a reasonable length of time (varying, of course, with the individual and with the character of the deposit) will suffice to lift any report far outside the realm of guess-work.

While the prospector or vendor usually errs by reason of an absurd optimism, the educated engineer often errs as widely in offering ambiguous (and consequently worthless) reports as a function of his lack of experience; at a time, too, when, of all others, he should remember the old class-room method and honestly say "Yes," "No" or "Not prepared."

Since the discussion of localization of ore-values directly implies consideration of sampling methods, the fact may serve as

an excuse for the recital of an experience which resulted in unexpected discordance in results: A large and (as far as its appearance went) rather unusually homogeneous quartz vein was to be sampled. It averaged about 5 feet in thickness and was exposed in an 800-foot shaft and about 3,000 feet of drifts; the vein being unusually regular and well-defined, with good walls, from which the ore broke easily. Below the zone of surface oxidation (about 100 feet) the appearance of the vein at all points was quite similar, and later acquaintance proved that occasional appearance of increased mineralization was by no means indicative of alteration in values. Some 300 samples were carefully taken, crushed, sampled down and assayed; showing wide variation in values of even contiguous samples all through the mine. A re-assay of the samples, in addition to the assay of various further samples, established the truth of the first results and indicated a distribution of values throughout the vein very decidedly "without rhyme or reason." In the absence of any explicit rules for use in such a condition, it may be imagined that the deduction of a safe commercial average value from such a series of widely-varying results supplied all of the elements of a difficult problem. At such times one is frequently aware of an ulterior sensation comparable to that produced by a suspicion of "salting" and which naturally exacts additional care. After eliminating all unusually high samples, applying all of the usual methods of averaging and deducting an almost unreasonable factor of safety, an average value was decided upon (which, by the way, was afterward found to be about three times less than that given by one former sampler, and about *eight* times less than that given by another) which, alas, later experience proved to be about 12 per cent. too high. In this experience one may recognize at least one element in the causation of my second axiom.

With general reference to localization of values in veins and other ore-bodies (limited, as before, to ores of the precious metals) it is safe to say that a "schedule of all possible instances" would be too bulky for publication. Eliminating localization of values in (1) Ore-chutes (for reasons before given) and in (2)

Placer deposits (since possibly a dozen general types might satisfactorily cover the subject) consideration may then be confined to ordinary vein-deposits, with the conclusion that the varying conditions in this class are countless, since it is not far from the truth if the statement be made that no two precious-metal veins are alike. Slight differences in local or regional igneous action produce (or permit) radical differences in ore-deposits separated from each other by only a few yards, and the subject might be rendered still more complex if, in addition to localization, the item of altered mineralogical conditions in adjoining deposits be brought into consideration. As an example, one case is remembered where, in a zone roughly measured as 1½ miles long and 150 yards wide, within the limits of one ore-deposit, certain causes (which were ascribed to intrusions of differing igneous rocks) not only produced different conditions of localization of values, but also the following differences in mineralization: (1) Northern portion. Values in the ore almost entirely in the form of silver chloride, with very little gold. (2) Middle portion. Values almost entirely in gold, with the following differences in adjoining, parallel deposits: (*a*) Gold associated with sulphides and arsenides, with no tellurium; (*b*) Gold associated with tellurium and sulphides, with no arsenic. (3) Southern portion. Values largely in silver associated with tellurium, sulphur and arsenic; frequent occurrence of uranium minerals.

Further: one is enabled to recall many conditions of localization of which the converse is quite as liable to occur; such, for instance, as the following:

1. In which the values in the ore vary directly with the swell or pinch of the vein.
2. In which the values vary inversely with swell or pinch.
3. In which values increase or diminish materially with advent of a faulting vein or dike.
4. In which they do not.
5. In which alterations of values occur with alteration in mineral character of vein.
6. In which change in mineral character does not alter values.

7. In which vitreous quartzes carry the values, while opaque quartzes in the same vein do not.

8. The reverse of this condition.

9. In which values increase in depth.

10. In which they do not.

All the above will serve to prove little except the profound respect entertained by the writer for the subject at hand. As he has possibly already consumed more than his share of the space, he will close with the suggestion that, as sufficient ground for a fairly large discussion, someone suggest *one* case of localization of values, and submit it for general consideration and comparison.

F. C. SMITH.

SAULT ST. MARIE, ONT.,
March 26, 1908.

REVIEWS

Clays of Mississippi. By WILLIAM N. LOGAN. Mississippi State Geological Survey. Bulletin No. 2, 1907. Part I., Brick Clays and Clay Industry of Northern Mississippi. Pp. 255, 42 plates, 14 figures, 109 tables, geological map.

This report devotes approximately 150 pages to the general treatment of clays and the remaining 100 to geology and a detailed description of the clays in forty counties in the northern part of the state. The general, theoretical and technical phases of the subject are discussed under the following heads: Origin and Classification of Clay, Chemical Properties, Physical Properties, Processes of Manufacture, Fuels, Properties of Brick, and Imperfections of Brick. The geology occupies a chapter and the detailed discussion fills the closing chapter.

The author's general treatment of clays is concise and well arranged and his compact paragraphs and liberal use of headings make the information readily accessible. He has adopted an original introduction to the subject, the first pages being taken up with a description and classification of rocks under the terms regolith and durolith, the latter being a term that is new to the writer. The presentation of the mineralogical, chemical and physical properties of clays and processes of manufacture is similar to that of other works on the subject but the author has used excellent judgment in the selection and arrangement of the material. Fuel is treated in a chapter which contains an interesting discussion of calorific values of various fuels together with tables of values, composition and costs. After a discussion of the properties of brick a chapter is devoted to describing causes of defects in brick and methods of overcoming them. This segregation in one chapter of common difficulties in brick manufacture is perhaps the best illustration of the useful arrangement of

the report. The final chapter, which is preceded by a chapter on the geology of Mississippi, contains a description of the clays and clay industries of the northern part of the state.

In the discussion of the clays and clay industries all the plants in the counties examined are briefly described and results given of tests of clay from thirty or forty pits and of samples from about twenty-five undeveloped locations. These tests, in the opinion of the writer, do not give sufficient prominence to the physical properties of the clays. Careful chemical analyses are given of nearly every sample but the physical tests are in many cases incomplete or omitted. Moreover, some of the physical data are of doubtful value. For example the percentage of absorption of burned test pieces is usually given, but since absorption in the same brick may vary 20 per cent. or more according to burn alone and no description of the method of molding the briquettes or amount of firing is given, one is at a loss to know the bearing of the information. Despite lack of balance in the tests, however, the discussion of the clays examined contains excellent practical comments upon their adaptability for commercial use.

EDWIN F. LINES.

URBANA, ILLINOIS,
March 1.

Some Recent Literature on Petroleum.

The Production of Petroleum in 1906. By W. T. GRISWOLD. Advance chapter from Mineral Resources of the United States, Calendar year 1906. U. S. Geological Survey, 74 pages.

The Petroleum Industry of the United States. By various authors. Engineering and Mining Journal, January 4, 1908.

The Santa Clara Valley, Puente Hills and Los Angeles Oil Districts of Southern California. By GEORGE HOMANS ELDRIDGE and RALPH ARNOLD. U. S. Geological Survey, Bulletin 309, 266 pages.

Preliminary Report on the Santa Maria Oil District, Santa Barbara County, California. By RALPH ARNOLD and ROBERT ANDERSON. U. S. Geological Survey, Bulletin 317, 69 pages.

Geological and Oil Resources of the Summerland District, Santa Barbara County, California. By RALPH ARNOLD. U. S. Geological Survey, Bulletin 321, 93 pages.

Geology and Oil Resources of the Santa Maria Oil District, Santa Barbara County, California. By RALPH ARNOLD and ROBERT ANDERSON. U. S. Geological Survey, Bulletin 322, 161 pages.

Geology of Oil and Gas Fields in Steubenville, Burgettstown and Claysville Quadrangles, Ohio, West Virginia and Pennsylvania. By W. T. GRISWOLD and M. J. MUNN. U. S. Geological Survey, Bulletin 318, 196 pages.

One of the most striking features of the recent mineral production of the United States has been the enormous output of petroleum. This has practically doubled in the last five years and now reaches the enormous total of 166,000,000 barrels, having a value of approximately $125,000,000 in the crude state. The general features of recent production are shown in the table below in which the figures for 1902 and 1906 are taken from the reports of the U. S. Geological Survey, and those for 1907 are the estimates of the *Engineering and Mining Journal* except for slight modifications introduced on the basis of later figures from Illinois.

PRODUCTION OF PETROLEUM IN THE UNITED STATES.

(In barrels of 42 gal.)

	1902.	1906.	1907.
Mid-continental.....	368,849	21,718,648	47,556,906
California.....	13,984,268	33,098,598	40,000,000
Appalachian.....	32,018,787	27,741,472	25,500,000
Illinois.....	200	4,397,050	24,540,024
Gulf-costal plain.....	18,632,275	21,645,275	18,175,000
Lima (Ohio–Indiana)..	23,358,826	17,554,661	8,030,000
Others.....	403,911	338,082	2,238,070
Total..	88,767,116	126,493,786	166,040,000

These figures are not exactly comparable but they serve to indicate with fair accuracy the principal changes in production in recent years.

As is well known the Appalachian field was for many years the sole producer and later long maintained a dominant position

in the industry. The production has now been practically stationary since 1880 and is at present declining. Not even extra inducements in price and grading have stimulated development enough to bring in new production as fast as old wells cease to flow and of the 7,053 new wells drilled in 1907, 27 per cent. were dry, while the new daily production per well drilled amounted to only 6.1 barrels. In southeastern Ohio 39.5 per cent. of the wells drilled were dry. These figures indicate clearly that the high grade oil fields of the east are unable to respond to the demand for increased production and that other parts of the country must be relied on to make good the deficiency. Fortunately there seems to be no lack of good oil territory elsewhere. Aside from the Lima field, where the recent decline has been sharp and significant, the various fields either show an increase in output or are clearly capable of yielding more oil if development be pushed. The Illinois field is increasing in production at a rate which compensates for the decrease in the Lima field and the mid-continental field has increased so much more rapidly than the oil could be cared for that serious difficulties have arisen.

Mr. Griswold's figures enable the rise and fall of the various fields to be studied in detail and he has included a number of important tables, including a very interesting one from the report of the Commissioner of Corporations, showing the percentage of approximate average yield of leading products from different kinds of crude oil by fields. In a few places Mr. Griswold's figures are inconsistent but in general the report is clear and the matter well presented.

In view of the declining production in the east the report on the Steubenville-Burgettstown gas and oil fields will be of large local interest. It is at the same time of general interest as showing the results of a very refined method of investigation, applied to a field varied in character. The report includes topographical, geological and structural maps which make it possible to determine the depth to each sand at any point. The maps also show the relations of the oil and gas pools to structural features. Mr.

Griswold summarizes his conclusions, based upon a general study of the whole region as follows:

"(1) In dry rocks the principal points of accumulation of oil will be at or near the bottom of the synclines or at the lowest point of the porous medium, or at any point where the slope of the rock is not sufficient to overcome the friction, such as structural terraces or benches. (2) In porous rocks completely saturated the accumulation of both oil and gas will be in the anticlines or along level portions of the structure. Where the area of porous rocks is limited the accumulation will occur at the highest point of the porous medium, and where areas of impervious rocks exist in a generally porous stratum the accumulation will take place below such impervious stop, which is really the top limit of the porous rock. (3) In porous rocks that are only partly filled with water the oil accumulates at the upper limit of the saturated area. This limit of saturation traces a level line around the sides of each structural basin, but the height of this line may vary greatly in adjacent basins and in different sands of the same basin.

"Partial saturation is the condition most generally found, in which case accumulations of oil may occur anywhere with reference to the geologic structure; it is most likely, however, to occur upon terraces or levels, as these places are favorable to accumulation in both dry and saturated rocks.

"Under all conditions the most probable locations for the accumulation of gas are on the crests of anticlines. Small folds along the side of a syncline may hold a supply of gas, or the rocks may be so dense that gas can not travel to the anticline, but will remain in volume close to the oil."

These various conditions are illustrated by a diagrammatic section introduced below. (Plate I., Bulletin 318.) It is impossible at this place to review the evidence upon which these conclusions are based. For that the reader must refer to the original text.

So far only preliminary reports upon the Illinois and the mid-continental fields are available. The Gulf coastal plain fields have been described in reports by Hayes and Kennedy and by

Fenneman and now a large mass of data regarding the California districts is at hand.

The present reports cover approximately half of the known oil regions of California. The Coalinga district and the various Kern County fields are yet to be reported on. The study of the California oil fields was begun by Mr. Eldridge in 1901 and active field work was carried on for about one year with a view to the preparation of a monograph covering the petroleum deposits of the whole state. His subsequent poor health and his death in 1905 interrupted the work.

His successor, Mr. Arnold, has prepared for the press Mr. Eldridge's reports upon the Santa Clara and Puenta Hills districts substantially as written by him. In the other districts the time since the field work was carried on has made it necessary largely to execute new surveys.

The reports as presented are substantially preliminary in character as regards any general conclusions regarding the laws which govern the accumulation and distribution of oil and gas. They give a large amount of valuable information on the geology of the fields and the facts of the occurrence but they leave room for a general summary discussion which should contribute to scientific theory and be of interest to geologists everywhere. Presumably Mr. Arnold is very properly holding this open until the completion of the survey of the remaining fields.

"The formations of the Santa Clara Valley," according to Eldridge, "include certain Pleistocene beds of which the precise horizon is not determined, a great series of conglomerates, sandstones and arenaceous clays which were designated by Hamlin some years since as the Fernando formation and which probably represent all of the Pliocene and overlap into both the Miocene and the Pleistocene; the Modelo formation, of sandstones and shales, which may prove to be the homologue of the Monterey; the Vaqueros formation, of shales, interbedded limestones and sandstones; the Sespe formation, in the main a great body of brownish-red sandstones and conglomerates; the Topatopa formation, of quartzites, sandstones, and hard, more or less siliceous, and earthy shales; and an older basement of gneisses and gran-

ites, probably of Jurassic age. This series of formations appears to be conformable from the base of the Topatopa as far up as the base of the Fernando, where a distinct chronologic break is observable. The later Pleistocene, also, is uncomformable with the beds below, resting here upon one formation, there upon another."

The district includes a number of different oil fields and oil occurs in the Modelo shales, Fernando sands, Sespe red beds and even in the crystalline schists which overlie the San Gabriel granite in Placerita Canyon. The oil here is very light, 50°, and was discovered in shafting for gold. One well is said to have spouted when first struck. The yield is five or six barrels per day with thirty to forty barrels of water to each barrel of oil. Concerning its origin Mr. Eldridge makes the following suggestion:

"The presence of oil under conditions similar to those that exist here is perhaps unknown in any other part of the world. It occurs from 400 to 1,000 feet beneath the surface in a steeply dipping and close-textured crystalline schist. That a reservoir, even though small, exists in such rocks must be due, it would seem, to the fracturing of the schist, the natural result of the severe contortion to which it has been subjected. If the oil originated in the schist, or rather in the sediments from which the schist was metamorphosed, it is beyond comprehension that it should have remained in them under tremendous pressure and heat to which the strata have unquestionably been subjected. Indeed, it seems to be an impossibility that such can be the history of its development. Moreover, the gravity of the oil, between 50° and 60° B., is equally enigmatical. Even if it was originally a high-gravity oil, the lighter hydrocarbons would have been the first to be given off in the heat, pressure, and fracturing to which the rocks have been subjected, and if anything remained it should have been the asphaltic or paraffin residue. It may be that the oil is of later origin, or, in any event, that it was for a time stored in another reservoir, perhaps of Vaqueros age, possibly even of Fernando age. It is possible that from such a reservoir the light oil, already from some cause separated from

the heavy oil, may have found its way between the two formations and penetrated the crystalline rocks through one of their fractured zones."

GEOLOGIC FORMATIONS.

TENTATIVE CORRELATION OF OIL-BEARING FORMATIONS OF SOUTHERN CALIFORNIA WITH THE STANDARD CALIFORNIA GEOLOGIC SECTION.

Period.	System.	Series.	Standard California Section.	Santa Clara Valley.	Los Angeles.	Puente Hills.
CENOZOIC	Quaternary	RECENT	Alluvium	Alluvium	Alluvium	Alluvium
		PLEISTOCENE	San Pedro	Sand and gravel	Sand and gravel	Sand and gravel
	Tertiary	PLIOCENE	Unconformity Merced Purisima San Pablo	Unconformity Fernando	Unconformity Fernando	Unconformity Fernando
		MIOCENE	Unconformity Monterey	Unconformity Modelo { Shale; Upper Sandstone; Lower Sandstone }	Unconformity Diabase intrusion Puente { Upper shale; Sandstone; Lower shale } (?)	Unconformity Diabase intrusion Puente { Upper shale; Sandstone; Lower shale } (?)
		OLIGOCENE	Vaqueros San Lorenzo	Vanqueros		
		EOCENE	Unconformity Tejon Martinez Unconformity?	Sespe { Upper; Red beds; Lower } Topatopa		
MESOZOIC	Cretaceous		Chico Horsetown Knoxsville	(?)		
	Jurassic		Unconformity Granite rocks of the Sierra Nevada	Unconformity Granitic rocks of the San Gabriel	Unconformity Granitic rocks of the Santa Monica Range Black schist	

An interesting feature of the discussion of the Puente Hills district is a table showing the variations in daily yield from certain groups of wells. This table is reproduced below (Bull. 309, Pl. XVII., U. S. G. S.). Such data are highly desirable and are

of large service in any quantitative discussions of geology. It is to be hoped that similar charts may be prepared for other fields.

Mr. Arnold introduces his discussion of the Los Angeles field with a table of geological formations as follows.

The formations principally important from the point of view of oil production are the Monterey and its correlatives. Indeed, the oil wells are almost entirely in this formation or in more recent beds which overlie it. The exceptions include the oil in the schist already discussed and the wells in the Sespe and Topatopa of the Santa Clara valley. Many of these are in such situations as to suggest leakage from other beds.

The accumulation of the oil seems to have been largely controlled by structural features. For example Mr. Arnold says:[1] "The Los Angeles oil field is developed in strata at the top of the Puente formation on the southern limb of the great Elysian Park anticline. . . . The oil appears to have accumulated in the sands of the southern limit of the anticline just below the point where the steeply dipping beds bend toward the horizontal before passing over the axis of the fold." Again he says:[2] "In the Santa Maria and Lompoc fields the evidence indicates that anticlinal structure is favorable although probably not absolutely essential to the accumulation of oil." In discussing the Summerland district he further says:[3]

"In one of the Cone wells, in the eastern part of the town, the gas occurs at 600 feet below the surface, while oil is obtained 25 feet farther down. This occurrence, together with the general position of the gas wells at the top of the Summerland monocline, is interesting in substantiating the theory that wherever oil and gas occur separately in the same bed the gas will always be found at the top. In fact, the Summerland field as a whole furnishes a good illustration of the conditions postulated by the anticlinal theory, which states that where water, oil and gas are found separately in the same bed the water will be found lowest, the oil next, and the gas at the top."

[1] Bull. 309, pp. 156–157.
[2] Bull. 322, p. 72.
[3] Bull. 321, p. 49.

Structure is, however, not the only condition to be taken into account, both the porosity of the rock and the water content being important. Concerning these points Mr. Arnold's statement of the conditions in the Santa Maria fields is most illuminating:[1]

"The fields of the Santa Maria district are not yet old enough to make it ascertainable whether water occupies lower levels in the same porous strata in which the oil is contained, or strata below those containing the oil, and whether water will take the place of the oil on its exhaustion in the wells; or, on the other hand, whether the oil occurs unassociated with water in large amounts. What evidence there is throws doubt on the assumption that water is present in sufficient amount materially to affect the position of the oil in the strata. Although over a hundred wells have been sunk to depths ranging between 1,500 and considerably more than 4,000 feet in various positions relative to the axes of folds, water has been reported in only four wells at a depth of more than 1,000 feet below the surface, or below sea level, and in only a few wells below 300 or 400 feet. In other words, whatever water is present occurs in all but four wells near the surface, or at least considerably above the oil-producing zones.

"It may be questioned whether the presence of water is essential for the accumulation of petroleum in the upward folds of the strata under the conditions presented by the Santa Maria and Lompoc fields. Here the oil tends to rise to the surface and form seepages wherever channels of escape are offered. This is probably not due to hydrostatic pressure, as there is no evidence that the water tended to rise in the same way; and it is just the opposite of the tendency ascribed to oil by upholders of the anticlinal theory, which would result in the oil descending and gathering in the synclinal troughs on subsidence or removal of the water. In the fields under discussion the oil is always intimately associated with gas. There do not seem to be, as a rule, separated stores of gas and oil, but the two are intermingled, or at least closely brought together, so that one is not usually found

[1] Bull. 322, pp. 72–73.

without the other, although gas is sometimes found alone. The oil exhibits a tendency to migrate, as shown by its original concentration from widely separated points of origin, by its surface seepage, and by the energetic way in which it rises in the drill holes when a source of it is tapped. This migratory faculty may be ascribed entirely to the presence of the associated gas, which would cause the oil to fill every crevice offering a point of escape or a point of lodgment. If this is granted, it is evident that the points of accumulation of oil will be determined chiefly by the presence of cavities, large or small, offering a place for it to gather. Anticlines, being points of fracturing and in some places opening of strata, would afford likely places for the oil to lodge in those beds subject to fracture and for it to be imprisoned by overarching impervious beds.

"Aside from ideas as to accumulation of oil after such a fashion, the writers have come to the conclusion that in this region many of the 'oil sands,' so called, are not true sands, but zones of fractured shale or flint offering interspaces in which the oil can gather. Beds of sand in the Monterey are scarce and thin. Some of the oil-producing zones are very thick, amounting to tens or even hundreds of feet. The oil occurs chiefly in the lower portion of the formation, where brittle, flinty shale is abundant; and as it is a noticeable fact that wherever these hard, flinty layers appear at the surface they are usually much more contorted and fractured than the associated softer shales, which are, in general, only folded and not broken, it seems likely that the same fracturing and resultant formation of an ideal reservoir for the oil takes place in the depths as at the surface. Where it is so fractured, the shale occupies a greater volume than before, showing spaces some of which are open and others partially or wholly filled with chalcedonic or bituminous material. The unfractured beds are more or less impervious to the rapid migration of the petroleum, and so act as barriers to keep the oil in the porous zones.

"It is therefore possible that in the Santa Maria district the gas pressure is the chief agent in giving the oil mobility, and that the condition of the rocks is the chief factor that controls

the matter of where the oil is stored most abundantly. Hydrostatic pressure may not play an important part. The especially large accumulations in anticlines may be accounted for primarily by the cavities offered by the strata along upward folds, and secondarily by the presence of less pervious beds arching over such folds and affording favorable conditions for the confinement of oil and gas tending to escape. Lesser stores of oil may occur at other points within the formation."

The clearest statement regarding the supposed origin of the oil is given in the discussion of the Summerland fields.[1]

"The oil in the Summerland field originates by a slow process of distillation from the diatoms and other organisms in the Monterey (middle Miocene) shale, which is abundantly developed in the region. After its formation quantities of the oil migrate upward, largely through joint cracks, under gas or hydrostatic pressure, and accumulate in the Fernando formation in porous sandstones under relatively impervious clay layers. The reason that the oil does not continue its upward migration through the Fernando to the surface is because the plastic condition of certain clay beds in that formation precludes the production of cracks that could act as channels for the oil.

"The oil deteriorates with upward migration both in the Monterey shale and in the Fernando formation. This deterioration in the Monterey is exemplified by the Rincon well, which yields oil of 20° gravity, whereas heavier oil and even asphaltum is obtained at the neighboring Monterey outcrops.

"An apparent anomaly occurs in the Becker wells, heavy oil of 13° or less occurring down the dip below and in the same sand with the 15° oil. Another apparent anomaly is shown in the Oxnard section (Pl. VIII., section C), in the occurrence of 15.5° oil in the Miller wells at a much higher point than the 14° oil in the wells out on the wharf. This occurrence may be explained on the hypothesis that the Miller oil migrated upward through the joint cracks in the heart of the Loon Point anticline rather than into sand A at points on its flank and thence up

[1] Bull. 321, pp. 51–52.

along the sand stratum. An alternative but less likely explanation of such phenomena is that for some reason the oil loses in gravity as it passes upward in the steeply dipping beds, while in beds of low dip the lightest oil is found at the top. Other things being equal, it is generally true that lighter oil comes from the finer sediments."

In conclusion it is interesting to observe that the writers of these bulletins find it possible to explain the origin and occurrence of this wide variety of oils without recourse to any theory based upon volcanic agencies. If Mr. Arnold's complete and final studies fortify him in his first conclusions it will be fair to eliminate any such hypothesis from the California fields at least and they, as has perhaps been sufficiently indicated, are among our most productive.

Report of the Commissioner of Corporations. Transportation of Petroleum. By JAMES RUDOLPH GARFIELD. May 2, 1906, 512 pages. The Petroleum Industry, Herbert Knox Smith, May 20, 1907. Part I, 396 pages.

While these reports are mainly devoted to the costs of transportation of petroleum and the relations of the Standard Oil Co. to the industry, they contain much which is of interest to geologists and teachers of economic geology. For the latter especially it is important to have at least a general notion of the commercial relations of the producing districts. This can be easily obtained from the charts and tables published in these reports. There is also a brief general account of the refining process and of the products derived.

Oil and Gas in Kent. By C. W. KNIGHT. Rept. Bureau of Mines, Part I, Ontario, 1907, pp. 92–104.

The recent finds of oil and gas in Kent county are summarized briefly. There are two fields recognized, the Tilbury and the Romney. From the point of view of production the former

is the more important, producing in June 1907, 35,654 bbls. as against 3,163 for the Romney. The total production for the first six months in 1907 amounted to something over 390,000 bbls. and it was estimated that they would yield 30,000 bbls. a month, for the next 10 months. The oil is high grade. The Tilbury oil in bulk is dark olive green and runs 38 to 41 Baumé. The Romney oil has a high percentage of sulphur and runs 28 to 30 Baumé. Coste is quoted on the geology to the effect that in the Tilbury field drilling has so far extended downward into the Guelph and Magara only. Gas and oil are found in the Onondaga, Guelph and Magara, the wells being approximately 1400 feet deep.

The Romney pool has at shallow depths 200 to 270 feet "in the upper part of the Corniferous formation."

The Natural Hydrocarbons. By F. W. Clark. Chapter XVI of Bull. 330. U. S. Geol. Survey.

The chemical problems involved in the geology of petroleum and its associated compounds have recently been summarized by Clark in one of the chapters of his very interesting and valuable volume on the Data of Geochemistry. His conclusions may be briefly summarized as follows.

It is known that natural gas, petroleum, bitumen and asphaltum are mixtures of compounds of carbon and hydrogen. All fall into a number of regular series, to each of which a generalized formula may be assigned. Members of eight such series have been discovered in petroleum and tables are given showing the composition of many representative oils. Nearly all petroleums contain nitrogen from a trace up to 1 per cent. and over. Petroleum free from sulphur is extremely rare but the amount is commonly very small. Between liquid petroleum and solid asphalt there are numberless intermediate substances. Hydrocarbons have been repeatedly prepared by laboratory methods from inorganic sources and also by the breaking down of more complex organic matter.

The theories of the origin of petroleum may be divided into

inorganic and organic. Of the former that of D. Mendeléef, published in 1877, is representative. He presupposes the existence of iron carbides within the earth to which percolating waters gain access, generating hydrocarbons. If such carbides exist at reasonable depths below the surface of the earth, the suggested reactions would presumably take place; but the actual existence of the carbides remains to be proved. This and other inorganic theories relate not only to its proximate genesis but to fundamental questions of cosmology. If the molten globe had at any time a temperaturue like that of the electric furnace, carbides, silicides, nitrides, etc., would be among the earliest compounds to form, and oxidation could not begin until later. Under such conditions some carbides might remain unoxidized through many geologic ages, to be reached by percolating waters at the present day. The development of hydrocarbons would then inevitably follow, although to what extent they might subsequently be consumed no one can say. The theory is plausible, but is it capable of proof? Furthermore, does it account for any accumulation of petroleum such as yield commercial oils of to-day? We may admit that hydrocarbons are formed within volcanoes, but the quantities traceable to such a source are altogether insignificant. They are, moreover, absent, at least in significant proportions, from the Archean, and first appear abundantly in Paleozoic time. From the Silurian upwards they are plentiful, and commonly remote from great indications of volcanic activity.

Admitting that methane is sometimes formed as a volcanic emanation, we must recognize the fact that it is more commonly of organic origin. From field occurrence and laboratory demonstration it is evident that hydrocarbons analogous to natural gas, petroleum and asphalt may be derived either from animal or vegetable matter or from both.

It has long been known that some petroleums are able to rotate a ray of polarized light sometimes to the right and sometimes to the left. According to Walden only oils derived from organic matter can possess this property. His conclusions are

exceedingly important, but need to be more thoroughly tested. The presumption is strongly in their favor.

In any attempt to discover the genesis of petroleum the quantitative adequacy of the proposed sources must be taken into account. As Orton has said, disseminated petroleum is well-nigh universal; the accumulations are rare. His computations and those of Sterry Hunt lead to the conviction that the formation of petroleum is a general process. Wherever sediments are laid down, inclosing either animal or vegetable matter, there bitumens may be produced. The presence of water, preferably salt, the exclusion of air, and the existence of an impervious protecting stratum seem to be the essential conditions. By whatever class of reactions petroleum is generated, it doubtless appears first in a state of dissemination.

Nearly all of the proposed theories embody some elements of truth. The organic origin of petroleum, however, seems to be best supported by the geologic relations of the hydrocarbons, which are found in large quantities only in rocks of sedimentary character. There is no evidence to show that any important oil field derived its hydrocarbons from inorganic sources.

Professor Clark's conclusions are worthy of marked attention as being the careful summary of a large mass of conflicting evidence, by one eminently qualified to judge. It is interesting to note that he finds little direct evidence for the inorganic origin of oils and even says, "the association of gas, oil, salt, sulphur and gypsum, which some writers have taken as evidence of former volcanism, is much more simply interpreted, both chemically and geologically, as due to the decomposition of organic matter in shallow, highly saline waters near the margin of the sea." The exact process of decomposition of the organic matter is nowhere discussed and in view of the impossibility of an appeal to higher temperature and pressure in many of the important American fields, this omission is to be regretted. It has been suggested that biotic changes must be taken into account and studies of bacterial action are much needed. It is hoped that paleontologists may in time supply this information. It is also true that the problem of slow chemical change at low tem-

perature needs investigation and may afford data. Professor Parr has recently been obtaining interesting results from the study of the decomposition of coal in inert atmospheres at low temperatures and similar studies of ordinary sediments might lead to important results. This omission, however, in no way detracts from the great value of Professor Clarke's work, a value which is greatly increased by his very full references to literature.

H. Foster Bain.

The Great Fitzroy Copper and Gold Mine, Mount Chalmers (Rockhampton District). By B. Dunstan. Queensland Geological Survey, Publication No. 216, Brisbane, 1907. 67 pp. with 15 plates.

Mount Chalmers is about ten miles northeast of Rockhampton and nearly the same distance from the coast. The prevailing rocks are said to belong to the Gympie series of Permo-Carboniferous age and to comprise shales, quartzites and intercalated basic rocks. There is much local alteration, some of the shales containing up to 10 per cent. of barite or witherite associated with sphalerite and galena. The so-called quartzite is also described as probably a silicified limestone.

The ore occurs as irregular bodies in the quartzite, there being a gradation from this rock into nearly solid masses of sulfides. The disseminated ore in a siliceous gangue contains the more gold and silver while the massive sulfides are the more cupriferous. The latter ore shows in places a pronounced foliated structure, bands of sulfides curving around lenticular masses of a reddish jaspery rock which is supposed to represent metasomatically altered serpentine. In other words the view is advanced that the ore is a metasomatic replacement of interbedded limestone and serpentine, the serpentine being changed to massive sulfides and red jasper, and the limestone to "quartzite" with disseminated sulfides.

The Mount Chalmers deposits were discovered in 1860 but have never been extensively worked—the total output up to 1907 amounting to only about $16,000. They are now under de-

velopment by a new company, with workings extending to a depth of 220 feet. The ore reserves to this depth, as estimated by the author of the report under review, are about 145,000 tons averaging about 4½ per cent. of copper and containing 0.17 ounces of gold and 1 ounce of silver to the ton.

This report is typical of many issued by the geological surveys of Australian states. The reader who picks up such a publication finds a brief geological introduction, often fairly tantalizing in its incompleteness and, before he can gain any general conception of the district described, he is hurried underground and guided through drives, crosscuts and shafts with a wealth of circumstance in the way of distances, assays, dips, fluccan and mullock that is appalling to any but an owner or prospective purchaser of the mine described. In the present report one looks in vain for any general statement of the geological structure of the field. The metasomatic alteration associated with ore deposition is apparently of rather unusual character but it receives scant attention and no microscopical study; nor is the genesis of the ore bodies more than hinted at. There is no statement of the mineralogical composition of the ore although the reader may infer that it consists of pyrite and chalcopyrite with more or less sphalerite and galena.

As usual in reports of this character, there are many maps and plans, mostly of mine workings. There is, however, no geological map, although one of the sections through the workings exhibits fairly well some of the structural relations of the ore bodies. A separate plan of each level is published in color, some of these being on the scale of 15 feet to the inch. What purpose is served by these plans and why money was wasted in printing in colors what would have been equally effective as black and white cuts, are questions which the reviewer is unable to answer.

This official report, in short, might well have been modelled after such a statement as is published annually by many a large mining company for the information or entertainment of its stockholders. If it were indeed a document of this character it might be criticised from a different plane. As an official report from a geological survey, however, it may serve as the

text for candid comment on the whole class of publications of which it is a fair example, and as an occasion for the friendly expression of a hope for better things—for reports in which field-work has borne fruit, in which illuminating conclusions find clear and orderly presentation and in which detailed descriptions of mine workings, pruned of non-essentials, are grouped in a separate part of the report for reference by those especially interested in them. It is a pleasure to note the advance toward such an ideal manifest in late years in the publications of the New South Wales and New Zealand geological surveys.

F. L. RANSOME.

Peat: Essays on its Origin, Uses and Distribution in Michigan. By CHARLES A. DAVIS. Published by the State Board of Geological Survey as a part of the report for 1906, and a contribution also to the Biological Survey of the State. Authorized by Act 250, Session 1905. Lansing, Mich., 1907. Pp. 256, 19 plates, 19 figures.

This is by far the most important contribution to the subject of the origin, distribution and uses of peat, that has appeared in this country. The people of Michigan are singularly fortunate in having a state organization ready to undertake work of this kind, and in securing the services of such a man as Professor Davis to carry it out. Professor Davis has the advantage of good geologic training and experience, and of being at the same time an expert botanist. In addition to this rare combination, he is a keen observer, and possesses a high appreciation of the practical every-day value of scientific work which enables him to make application of all his scientific data.

The interest in peat as a possible source of fuel and other commodities is attracting widespread attention, with the result that various other states are giving attention to the matter and endeavoring to map the peat deposits within their borders, and to stimulate the interest of the citizens in what has heretofore been regarded as not only valueless, but as a blot on the landscape. Already such reports have been issued by New Jersey, New York, Iowa and Indiana; but in none of these has the subject been

treated in the comprehensive manner that it has been in the Michigan report.

The paper of Professor Davis is divided into three parts. Part I. treats of the "The Ecology of Peat Formation in Michigan." As indicated by the title, this part is devoted to a discussion of conditions which may result in the formation of peat, and of the plants which have contributed to it.

He presents several schemes for the classification of peat bogs. One is based upon the form of the land surface upon which the bogs grew, and another is dependent upon the character of the surface vegetation. From a study of the former the observer is enabled to tell something of the probable extent of the bog and of the depth of peat composing it. From the latter he may soon learn to distinguish peat bogs by the character of the vegetation growing upon them.

The most important part of the paper is the thorough discussion of the various modes of peat formation and the plants chiefly concerned in each case. This involves building up from the bottom in certain cases, and the development of the surface mat in others. From these simple cases he carries the discussion into the more complicated conditions involving a change of water level, and he shows by diagrams the results from the various conditions of growth of deposition.

The popular impression that *Sphagnum* is the chief peat-forming plant is rudely shaken by Professor Davis' conclusions, which are as follows:

"The foregoing discussion makes it evident that in the Southern Peninsula of Michigan, peat is chiefly formed by plants which grow below or very near the water level, aquatic plants in connection with sedges, and other grass-like plants; *Sphagnum* does not appear until late in the history of the formation, if at all, and develops only shallow, superficial layers of peat and usually grows best in association with certain shrubs, which may become prominent before the *Sphagnum* appears, and which may also reduce its effectiveness in peat-forming by developing dense shade."

He sums up the ecological factors controlling the succession of peat-forming plants as follows:

1. "Light: That which may be considered of first importance, since a wet habitat is assumed, is the light factor, because this limits the development of peat deposits through limiting the growth of plants, both below and above the water level."

2. "Soil: A second group of factors of importance are those termed the edaphic or soil factors. Both the physical and chemical characters of the substratum in which the underground parts of plants grow, are important in determining their distribution, and in many cases control the type of vegetation in a given area, or account for the presence or absence of certain types."

3. "Temperature: Heat is a third factor of importance, and its absence tends to reduce the number of species and the number and the size of individuals."

4. "Air: The difficulty of getting a sufficient supply of air from soil saturated with water or from water directly, excludes from the plant associations concerned in peat formation, all plants which do not have special adaptations or cannot develop them, for the purpose of getting oxygen under the conditions presented."

5. "Plants: . . . the influence of most species of plants upon some of those with which they are associated is important, in a greater or less degree, according to the closeness of the association and the extent to which they have the same or similar requirements, since each species exerts some influence upon all others with which it competes for light, air, soil and water."

Part II. is devoted to a description of the peat bogs of the Northern Peninsula, and should be of great value to anyone seeking raw material for development. This part is accompanied by two large maps showing the peat deposits of both the Lower and Upper Peninsulas. In addition, the map of the Upper Peninsula shows in color the character of the forests.

The principal criticism of these maps is that a part of the culture is printed in a weak, greenish-brown color which makes it

utterly unreadable in most places. The object appears to have been not to obscure the map. This object has been so well accomplished that the print might just as well have been omitted.

Part III. is devoted to the economics of peat. This feature will make the report of general interest, for many persons are raising the question "How can our deposits of peat be utilized?" Michigan has taken the lead in experimental work in this respect, but so far little of practical value has resulted. It is hoped, however, that under the stimulus of such a State Geological Survey the citizens of Michigan will take up this subject with renewed energy, and will demonstrate to the rest of the country that her peat deposits are a source of wealth and are worthy of careful study and investigation.

Professor Davis devotes most of his report to the consideration of peat as a fuel, and in summing up his conclusions he says:

"It is probable, as has been intimated elsewhere, that the best way in which quick and sure returns may be realized from peat bogs, is by developing them with the idea of supplying small local markets, rather than attempting to compete with better known and more widely used fuels on a large scale. Where the former course is taken, a relatively small bog, a small investment, and a local market, with a limited requirement in quantity, should make a combination which should be satisfactory to the owner and investor, who could then afford to give his customers a fair price, which should run considerably below that paid for ordinary fuels and still give good profit. When the numerous bogs of Michigan are thus utilized, as many of them will be before many years, the peat fuel industry will be placed upon a proper footing."

RECENT LITERATURE ON ECONOMIC GEOLOGY.

COMPILED BY

CHARLES H. CLAPP.

METALLIFEROUS DEPOSITS.

COPPER.

The Poderosa Copper Mine, Collahuasi, Chile. By R. HAUXHURST, JR. Eng. and Min. Jl. March 7, 1908. Pp. 490–491.

Cloncurry Copper Mining District. By L. C. BALL. Queensland Gov. Min. Jl. Dec., 1907 and Jan. 1908. 23 pp.

A Industria mineira no Sul do Tejo. By F A'A. D'OREY. Revista de Obras publicas e minas. Vol. XXXVIII., No. 448. Pp. 250–266. Lisbon, 1907.

GOLD.

The Auriferous Banded Ironstones and associated Schists of South Africa. By O. LETCHER. Brit I. M. M. Jan. 16, 1908. 12 pp.

Zur Zenntnis der Goldzecher Gänge. By CANAVAL. Erzbgb. Feb. 15, 1908. Pp. 70–75.

Osservazioni mineralogiche sui giacimenti auriferi di Brusson (Valle d' Aoste). By L. COLOMBA. Atti. R. Acc. Sc. XLII. Pp. 1–21 with 1 plate. Torino, 1907.

IRON.

The Native Ores of Jackson County, Ohio. By D. F. MORGAN. Iron Tr. Rew. Feb. 13, 1908. 1½ pp.

The Iron Ores of Ontario. By A. B. WILLMOTT. Can. Min, Jl. March 15, 1908. Pp. 77–84, with a map. (From the Jl. of the Can. Min. Inst., Vol. XI.)

Aus der chinesischen Eisenindustrie. By C. BLAUEL. Stahl u. Eisen. Jan. 1, 1908. 7½ pp. (Translation of above in Electrochem. and Met. Ind., Feb., 1908, 2 pp.)

Die Hämatitgruben bei Egremont und Frizington in Cumberland, England. By M. BALDUAF. Oest. Zeit. f. B. u. H. Jan. 18, 1908. 4 pp.

Die Eisenerzlagerstätten Württembergs und ihre volkswirtschaftliche Bedeutung. By R. FLUHR. Zeit f. prakt. Geol. Jan., 1908. Pp. 1–23, with a map and 10 figs.

Das Eisenerzlager von Banjeli ni Togo. By KOERT. Erzbergb. Feb. 15, 1908. Pp. 80–82.

LEAD.

Zinc and Lead Deposits of South Western Missouri. By F. L. GARRISON. Min. and Sci. Press. Vol. XCVI. Pp. 291–294, 325–328, with a map and 5 photos.

SILVER.

The Promontorio Silver Mine, Durango, Mexico. By F. C. LINCOLN. Bull. A. I. M. E. Jan., 1908. Pp. 83–99.

TIN.

Tin Mining in Tasmania. By J. B. LEWIS. Eng. and Min. Jl. March 7, 1908. Pp. 485–489, with a sketch map and 3 photos.

Die Zinnerzgruberlin in Cornwall bei Redruth und Camborne. By M. BALDAUF. Oest. Zeit. f. B. u. H. Jan. 11, 1908. 4 pp.

TUNGSTEN.

Giacimenti di minerali di tungsteno a Genna Gurèn ai limiti fra Nurri ed Orroli (cagliari). By D. LOVISATA. Rend. R. Acc. Lincei. (5), XVI., 1 sem., 8. Pp. 632–638. Rome, April 21, 1907.

NON-METALLIC DEPOSITS.

CEMENT.

Du Trass des Brohltales. By K. VÖLSING. Jahrb. d. Preuss Geol. Landesanst. No. 28, Berlin, 1907. Pp. 1–56, with 5 plates.

COAL.

Peat, Essays on its Origin, Uses and Distribution in Michigan. By C. A. DAVIS. Geol. Survey of Mich., Ann. Rept., 1906. Pp. 97–363, with plates XIII. to XXXI., and figs. 2–20.

Lignite of Mississippi. By C. S. BROWN. Miss. State Geol. Surv., Bull., No. 3. 1907. 71 pp.

Coal in Coahuila. By E. ORDOÑEZ. Min. and Sci. Press. March 14, 1908. Pp. 363–364.

Moose Mountain District, Southern Alberta. By D. D. CAIRNES. Geol. Survey of Canada, Ottawa, Canada. 1907. 62 pp.

Handbuch für den Deutschen Braunkohlenbergban. G. KLEIN, Editor. 504 pp., a geol. map of German 1: 1800000, 13 plates, and 204 figs. Knapp, 1907. Contributions by H. POTONIE, E. ERDMANN, K. KEILHACK, K. OBBEKE, M. KERNAUL, E. SCHÜTZE, L. VAN WERVEKE, G. FLIEGEL, A. STEUER, F. BEYSCHLAG, H. STILLE, O. V. LINSTOW, W. WEIFSERMEL, F. ETZOLD, E. MEYER, C. GAGEL, G. BERG, A. JENTZSCH. Extensive abstract in Geol. Centrabl., Feb. 15, 1908. Pp. 542–547.)

Uber Steinkohlenformation und Rotliegendes bei Landeshut, Schatzlar und Schwadowitz. By J. HERBING. Breslau, 1906. 88 pp., with 6 figs. and 2 plates.

Note sur l'exploitation du lignite en Roumaine, Margineanca. Rev. univ. des Mines, 1907, Vol. XX. Pp. 49–64.

Notizie sui giacimenti di lignite dell' Iglesiente. By B. GALDI. Pub. d. Corpo reale d. Miniere. 55 pp., with 18 figs. and 6 plates. Rome, 1907.

PETROLEUM.

Die neueren Ansichten über die Enststehung des Erdöles. By C. ENGLER. Reprint from Petroleum, 1907, Nr. 20–23. Berlin, 1907. 67 pp. Price 2M.

Die Petroleum—Weltproduktion. By N. MANCAS. Petroleum, II., 1907. Pp. 217–220.

Das Erdöl und seine Entstehung. By H. STREMME. Leipzig, 1907. 31 pp.

Exploitation du Petrole. By L. C. TASSART. 726 pp., illustrated. Dunod & Pinat, Paris, France, 1908.

Thèses sur la Formation du Pétrole. By C. ENGLER. Revue du Petrole. Jan. 8, 1908. 2 pp.

L'industrie des hydrocarbures en Italie. Pub. d. Corpo reale d. miniere. No. 25. 45 pp., with 5 plates. Rome, 1907.

GRAPHITE.

Mode of Occurrence of Canadian Graphite. By H. P. H. BRUNELL. Can. Min. Jl. March 15, 1908. Pp. 70–72. (From Jl. of the Can. Min. Inst., Vol. XI.)

Le minieri di grafiti e di piriti cuprifere nelle Alpi Cozie; contribute alla genesi. By F. RODRIGUEZ. 20 pp., with 7 plates. Torino, 1907.

PRECIOUS STONES.

A Preliminary Report on the Arkansas Diamond Field. By P. F. SCHENIDER. Bureau of Mines, Manufactures and Agriculture. 1907. 16 pp.

The Eruptive Diamond-Bearing Breccias of the Boshaf District, S. Africa. By J. P. JOHNSON. Brit. I. M. M. Jan. 16, 1908. 7 pp.

The Geology of the Roberts Victor Diamond Mine (Orange River Colony). By J. P. JOHNSON. Published by the author at Johannesburg. 1908. 13 pp.

The Vaal River Diamond Diggings. By M. PARK. Brit. I. M. M., Jan. 16, 1908. 4 pp.

SALTS.

The Saline Deposits of Carmen Islands. By E. H. COOK. Eng. and Min. Jl. March 14, 1908. Pp. 545–546, with 4 plates.

GENERAL PAPERS ON MINERAL DEPOSITS.

REGIONAL REPORTS.

The Historical Development of Colorado Veins from a Geological Standpoint. By T. A. RICKARD. Min. and Sci. Press. Feb. 29, 1908. Pp. 295–297, with 2 photos.

The Ore bodies of Etna Hill, Wis. By WHEELER. Min. Miner. Feb., 1908. P. 320.

Geological Survey of Michigan, Annual Report 1906. A. C. LANE, State Geologist. Sept. 10, 1907. 601 pp., with 35 plates and 26 figs.

Contents: **The Surface Geology of Portions of Menoninee, Dickinson and Iron Counties, Michigan.** By I. C. RUSSEL. Pp. 5–83. **Peat, Essays on its Origin, Uses and Distribution in Michigan.** By C. A. DAVIS. Pp. 97–363. **A Geological Section from Bessemer down Black River.** By W. O. GORDON. Pp. 401–503. **Cratægus in Southern Michigan.** By C. S. SARGENT. Pp. 513–567.

The Larder Lake District. By R. W. BROCK. Can. Min. Jl. Vol. 29. Pp. 621–624, 656–659, with 6 figs.

Die Erglagerstätte von Tsumet im Otaui-Bezirk in Norden Deutsch-Südwestafrikas. By W. MANCHER. Zeit. f. prakt. Geol. Jan. 1908. Pp. 24–32, with figs. 12–14.

Zur Geologie der kolumbianischen Mittel kordillere. By W. BERGT. Zentralbl. f. Mineral, etc. 1907. Pp. 720–722.

Die Sachsischen Erz- und Kohlenvorkommen. By W. MANCHER. Freiberg 1, Sa., Craz und Gerlach. 1907. 40 pp., with 8 figs. Price 1M.

Die Nutzlarmachung von Luftstickstoff. By L. GURWITSCH. Naturw. Wochenschr.. XXII., No. 42, 1907. Pp. 818–820.

Die Montanindustrie und das Elektrizitatswerk von Dohni Tuzla in Bosnien. By F. POECH. Zeit. d. österr. Ing- und Architektenvereins, Wein. Vol. 59; 1907. Pp. 453–456, and 476–480, with 15 figs, including 3 profiles and one map.

Du Erzbergban in Steiermark, Kaeruten, und Krain. (Austria-Hungary.) By DR. AHLBURG. Prenso Zeit. f. B. H. U. S. Vol. 55, No. 4. 1907. 61½ pp.

Die geologischen Verhältnisse du Bergzüge westlich und sudwestlich von Hildesheim. By A. WINDHAUSEN. Hildesheim, 1907. 18 pp., with 1 map.

Die Erzlagertstätten von Pitkäranta am Ladogasee. By O. TRÜSTEDT. Bull. de la Comm. Geolog. de Finlande, Helsingfors. 1907, No. 19. 333 pp., with 1 map, 19 plates, and 80 figs. Price 7.50M.

Les Richesses Minerales de Madagascar. By A. MERLE. Paris, 1907. 54 pp., with 1 colored map.

Aspecto Monero del Departamento del Cuzco. By E. F. DUENAS. Bol. del Cuerpo de Ing. de Min. de Peru. No. 53, 1907. 194 pp.

MINERALOGY AND PETROGRAPHY.

A Pyrrhotite Peridotite. From Knox County, Maine. A Sulphide Ore of Igneous Origin. By E. S. BASTIN. Jl. of Geol. Vol XVI., 1908. No. 2. Pp. 124–130, with 3 figs.

On the Formation of Quartz Under the Influence of High Temperature. By W. J. SOKOLAN. Trans. Russ. Royal Mineralogical Soc., St. Petersburg. No. 44, 1907. Pp. 473–482. (In Russian.)

Graphit und Molybdänglanz in Einschlüssen niederrheinischer. Basalte. By R. BRANUS. Centrabl. f. Min. Geol. U. Pal. Feb. 15, 1908. Pp. 97–104.

Sur l'origine de la Serpentine de la série cristallophyllienne de l'Averjron et du Gard. Comptes Rendus de l'Acad. d. Sciences. Vol. 144. P. 983. Meeting of May 6, 1907.

MISCELLANEOUS.

Co-Operation in Mining and Geology. By U. S. GRANT. Min. and Sci. Press. March 7, 1908. P. 333.

Report of the Director of the Mint upon the Production of the Precious Metals in the United States During the Calendar Year 1906. 134 pp. Washington, 1908.

Annual Report of the Director of the Mint for the Fiscal Year Ended June 30, 1907. 281 pp. Washington, 1907.

The Journal of the Canadian Mining Institute. Vol. X., 1907. Edited by H. M. LAMB, Secretary. 84 pp., illustrated. Montreal, Canada.

Report on the Department of Mines of Pennsylvania, Part I., Anthracite. Part II., Bituminous. J. E. RODERICK, Chief of Department of Mines. 653 and 974 pp., respectively. Harrisburg, Pa.

Report of the State Bureau of Mines of Colorado for the Years 1905–6.

E. L. WHITE, Commissioner. 126 pp., illustrated. Denver, 1907: State Bureau of Mines.

Progress in Wyoming Mines, 1907. By H. C. Beeler, State Geologist. Cheyenne, Wyo. Jan., 1908. 46 pp.

Ueber die umkehrbare Umwandlung des Kryoliths. By R. NACKEN. Centralbl. f. Min. Jan. 15, 1908. 2 pp.

Beiträge sur Kenntnis der chemischen Eigenschaften des Kalziummetalls. By H. VAN DE SMISSEN. Berlin, Techn. Hochsch. 1907. 34 pp.

Les méthodes paleontologiques pour l'etude stratigraphique du terrain houillee. By REMIER. Rev. univ. min. met. Jan., 1908. Pp. 1–57.

Rivista del Servizio minerario nel 1906. Pub. del Corpo reale delle miniere No. 24. 496 pp., with 4 plates. Rome, 1907.

SCIENTIFIC NOTES AND NEWS[1]

DR. H. F. BAIN, director of the Illinois Geological Survey, in a brief report issued recently, describes the condition of the oil fields in that state to the first of January, 1908. He estimates the total number of producing wells at 9,772, with 1,260 dry holes. At this rate 88 per cent. of the holes put down have proved productive despite the fact that the outlines of the fields at many points are yet to be determined. The daily production is estimated at 139,163 barrels. The oil occurs in a number of isolated pools which, however, are being brought closer together by drilling. Fortunately for all concerned the rapid and enormous development of oil production in Illinois has been accomplished in a thoroughly business-like and quiet manner. Leases sell at good prices and a fair royalty is demanded in the productive districts. At the same time there has been but little speculation by those unfamiliar with the oil business, and practically none of the usual stock-peddling companies were organized.

AT THE ANNUAL MEETING of The Mining Society of Nova Scotia held at Halifax, March 25–26, the main subject of discussion was the exploration of Nova Scotia's mineral resources. Among the speakers at the annual dinner were E. W. Parker, of the United States Geological Survey, Dr. Eugene Haavel and Dr. R. W. Brock, of the Mines Department, Canada, and Dr. W. G. Miller, Bureau of Mines, Ontario.

AN ESTIMATE BY E. F. BURCHARD, one of the geologists of the U. S. Geological Survey, places the red iron ore reserve of the main portion of the Birmingham district, Alabama, at ap-

[1] Geologists, mining engineers and others interested in applied geology are invited to keep the editor informed of new investigations of mining districts or scientific studies undertaken by them, together with such other scientific and personal items as may come to their notice.

proximately 340,000,000 long tons and at the present rate of production, it will last seventy-five to one hundred years longer.

As defined by Mr. Burchard, the Birmingham district includes the area from which the furnaces at Birmingham, Ensley, and Bessemer derive their iron ores, and is practically coextensive with the Birmingham Valley, the heart of the Alabama red-ore field. This valley extends from the vicinity of Springville, on the northeast, beyond Vance on the southwest, and from the Warrior coal field, or Sand Mountain, on the northwest, to the Cahaba coal field, or Shades Mountain, on the southeast. The valley is therefore nearly seventy-five miles long and as it has an average width of six miles it comprises an area of nearly 500 square miles.

The results of Mr. Burchard's study of this subject have just been published by the survey in an advance chapter from Bulletin No. 340, "Contributions to Economic Geology, 1907, Part I." This chapter is ready for distribution, and may be obtained by applying to the Director of the Survey at Washington, D. C.

AN UNDERTAKING involving an estimated expenditure of more than $160,000,000 which is being carried on in New York State, is the construction of reservoirs in the Catskill Mountains and of an eighty-mile aqueduct to furnish New York, Brooklyn and Staten Island with an additional daily supply of 500,000,000 gallons of water. One of the greatest problems in the construction of the aqueduct is that of crossing the Hudson River. The original plan was a tunnel under the river at Cornwall, fifty miles above New York. This tunnel would be driven from vertical shafts sunk in Storm King and Breakneck Mountains and would be a little over half a mile long. It has been the plan of engineers to prospect thoroughly the line of the aqueduct with diamond drills to determine the character of the ground and the depth to bed rock. The results of drilling in the bed of the Hudson River have been surprising. While the greatest depth of water is less than 100 feet, the rock bottom is found to descend abruptly beneath a mass of mud, sand boulders, and a drill hole in the middle of the river has failed to reach bed rock

at a depth of 580 feet. From the configuration of the rock floor however, it is believed by Prof. W. O. Crosby, of Boston, Mass., who is spending much of his time on the geologic problems in connection with this work, that the lowest point of the rock floor of the Hudson River valley opposite Storm King must be about 650 feet below the surface of the river. As the 17-foot circular concrete tube which will carry the water under the Hudson must be in bed rock in order to support the pressure, it will be necessary to sink shafts nearly 1,000 feet below grade level of the aqueduct in order to pass under the river in solid rock.

Drill holes in the valley of Moodna Creek west of Cornwall show that that stream is flowing on top of a thick deposit of sand and gravel filling a deep U-shaped rock valley. This ancient buried topography discovered by the drill may necessitate the construction of a single inverted syphon three or four miles long to go under both the Moodna and Hudson valleys instead of one under the Hudson alone as originally contemplated. The information obtained at great expense by diamond drilling has justified itself many times over in showing details of bed rock topography which in many places are hidden by thick glacial deposits and in showing strength or weakness of the rock at vital points.

DURING THE PAST YEAR as an outcome of certain stipulations in the bill appropriating funds for its work, the U. S. Geological Survey sent an unusually large number of parties into the Rocky Mountain region to investigate the extent and character of the coal deposits. It is thought that Congress will ask to have an equal volume of coal land classification done by the survey during the coming field season. The expense of outfitting the numerous parties put in the field last year was considerable, but now that the necessary horses and camp equipments are on hand the same amount of work of a similar character can be done this year at less cost.

Because of decreased expense of doing the same amount of work on the coal lands it is hoped that it will be possible to give

more attention during 1908 to the investigation of metalliferous deposits. Western mining camps did not receive their usual consideration from the survey in 1907 and demands are constantly being received from chambers of commerce, mining corporations and individuals for increased activity on the part of the survey in the gold, silver and copper camps of the west. These demands show how much the mjning public appreciates the scientific work done by the survey.

A NUMBER OF IMPORTANT reports by geologists of the U. S. Geological Survey which normally would have been published six months ago, are delayed on account of insufficient funds for printing. Although the greater number of these delayed reports are purely scientific and technical in character, others are almost wholly economic and the inability of the Survey to publish them at once is greatly regretted. It is hoped that with the beginning of the next fiscal year in July funds will be available to print all reports on hand.

A CONFERENCE of state geologists will be held in Washington, D. C., late in April or early in May. The exact date has not been fixed.

AT THE INSTANCE of Mr. H. M. Chance, of Philadelphia, an invitation has recently been extended to a number of mining engineers and geologists throughout the United States to become charter members of an association to have the title "Mining and Metallurgical Association of America." Among the charter members are the following men: S. F. Emmons, Pope Yeatman, J. Morgan Clements, James F. Kemp, Waldemar Lindgren, Forbes Rickard, T. A. Rickard, E. L. Dufourcq, J. E. Spurr, J. Parke Channing, A. H. Brooks, E. C. Palmer, F. L. Ransome, H. L. Smyth, E. Gibbon Spilsbury, H. V. Winchell. The object of the association is in some measure parallel to that of the American Society of Civil Engineers, *i. e.,* to offer a membership which shall consist of those men engaged in professional and scientific work who are of recognized professional or scientific standing. The first meeting, to be held in New York on April 20, will definitely formulate the policy and scope of the associa-

tion and, until then, it may be well to postpone a full presentation to our readers of its character, objects and organization.

AT A MEETING of the Geological Society of Washington, March 25, 1908, papers were read as follows:

The Eruptive Rocks of Mt. Bohemia, Michigan, by Mr. F. E. Wright.

Some Structural Details in the Pittsburg Region, by Mr. G. C. Martin.

The Mapping of Land Forms, by Mr. F. E. Matthes.

AT A RECENT MEETING of the New York Academy of Science, held in New York on April 6, a number of papers were read which are of some interest to economic geologists. They are as follows:

Salt Formations of Louisiana, by G. D. Harris, Cornell University.

Geology of Long Island, by W. O. Crosby, Massachusetts Institute of Technology.

Newark Copper Deposits of Eastern Pennsylvania, by Edgar T. Wherry, University of Pennsylvania.

Recent Advances in our Knowledge of the Magnetite Bodies at Mineville, by James F. Kemp, Columbia University.

AT A RECENT MEETING of the Canadian Mining Institute, held at Ottawa in March, 1908, among the papers read the following are worthy of mention:

Modes of Occurrence of Canadian Graphite, by H. P. H. Brumell, Buckingham, Que.

Some Notes on the Copper River District, Alaska, by Wm. M. Brewer.

Mining at Cobalt, by Frank C. Loring. mining engineer, Toronto, Ont.

Gold in the Eastern Townships of the Province of Quebec, by J. Obalski, Quebec.

The Iron and Steel Industry of the Province of Ontario, Canada, by Jas. G. Parmelee, Supervisor of Iron and Steel Bounties.

The Moose Mountain Iron Range, with Special Reference to the Properties of Moose Mountain, Limited, by Norman L. Leach, Sudbury, Ontario.

The Iron Ores of Ontario, by A. B. Willmott, Sault Ste. Marie, Ont.

The Iron Ores of Canada, by C. K. Leith, Madison, Wis.

THE FRIENDS of Mr. John Hays Hammond will be pleased to learn that he is rapidly recovering from his late operation for appendicitis. He is now in Santa Barbara and is already in better health than at any time in the past three years.

AT A DINNER given at the Columbia University Club, New York, on February 26, the graduates of the Columbia School of Mines took advantage of the occasion to demonstrate their esteem and appreciation of the scientific labors of Mr. S. F. Emmons, the guest of honor. Those present at this scientific gathering were James F. Kemp, presiding officer; John A. Church, Benj. B. Lawerence, J. H. Banks, J. Parke Channing, Robert Peele, A. L. Walder, Arthur S. Dwight, Joseph Struthers, F. M. Simonds, C. P. Berkey, E. C. Holden, A. C. Beatty, J. D. Irving, O. B. Perry, E. N. Skinner.

MR. F. B. WEEKS who has been connected with the U. S. Geological Survey for the past eighteen years has recently resigned. His address for two or three months while completing certain reports for the Survey will be 1201 Euclid St., Washington, D. C.

A. C. BEATTY is now examining the property of the Montgomery Shoshone Mining Co., at Rhyolite, Nevada.

THERE HAS RECENTLY been published by the Bausch & Lomb Optical Co., a neat little publication entitled "A Triple Alliance in Optics." This little publication not only contains a note of biographical interest but in a very entertaining way gives the evolution and science of optical appliances.

MR. W. ROLAND COX has recently been engaged inspecting the property of the Inde Gold Mining Company, Inde, Durango, Mexico.

A. J. COLLIER, of the U. S. Geological Survey, is again in Washington after making an examination of some gold and silver claims on the national forest lands in Oklahoma. These examinations are being conducted for the benefit of both the government and the claimants. Mr. Collier has been well chosen to make a complete and unprejudiced examination of these lands in question.

ARTICLES OF INCORPORATION have been recently filed in New York for an "American Iron and Steel Institute." The directors of this Institute are all of sufficient prominence in the iron and steel world to be familiar to every one, and in their able care there can be no doubt that the purposes of the Institute will be promoted to their best and fullest possibilities. The Directors include E. H. Gary, J. C. Maben, C. M. Schwab, William E. Corey, E. A. S. Clarke, W. J. Filbert, John H. Topping, Powell Stackhouse, E. C. Felton, Willis L. King, Edward Bailey, W. A. Rogers, J. F. Welborn, J. C. Drummond and Samuel Mather. E. H. Gary will be president of the Institute; Powell Stackhouse, first vice-president; C. M. Schwab, second vice-president; Willis L. King, third vice-president; W. J. Filbert, secretary, and Edward Bailey, treasurer.